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Construction of Dry Dock No. 4, Brooklyn Navy Yard

By H. S. Rinker.

The location of the New York Navy Yard, in the heart of the most important commercial and shipping center of the country, in close touch with the largest market for labor and material, emphasizes the need of adequate drydocking facilities in this Yard. Up to the time of the building of the dry dock known as No. 4, there were three dry docks located in the Yard, all of which were constructed only after overcoming great difficulties involving many failures and serious delays. The size of ships having increased rapidly of late years, these three docks had become too small to take the more recently built ships-of-war, making an additional and larger drydock necessary.

The need for such a dock being evident, its construction was authorized by Congress June 7, 1900, $1,000,000 being appropriated. The dock planned was 563 ft. long over all, 130 ft. wide at the coping, with a depth of 31 ft. above the sill at mean high water. The plan was in conformity with the general type of masonry drydocks, providing a gravity type of dock with mass-concrete inverted-arch bottom 11 ft. 9 in. thick, supported on piles driven over the entire area.

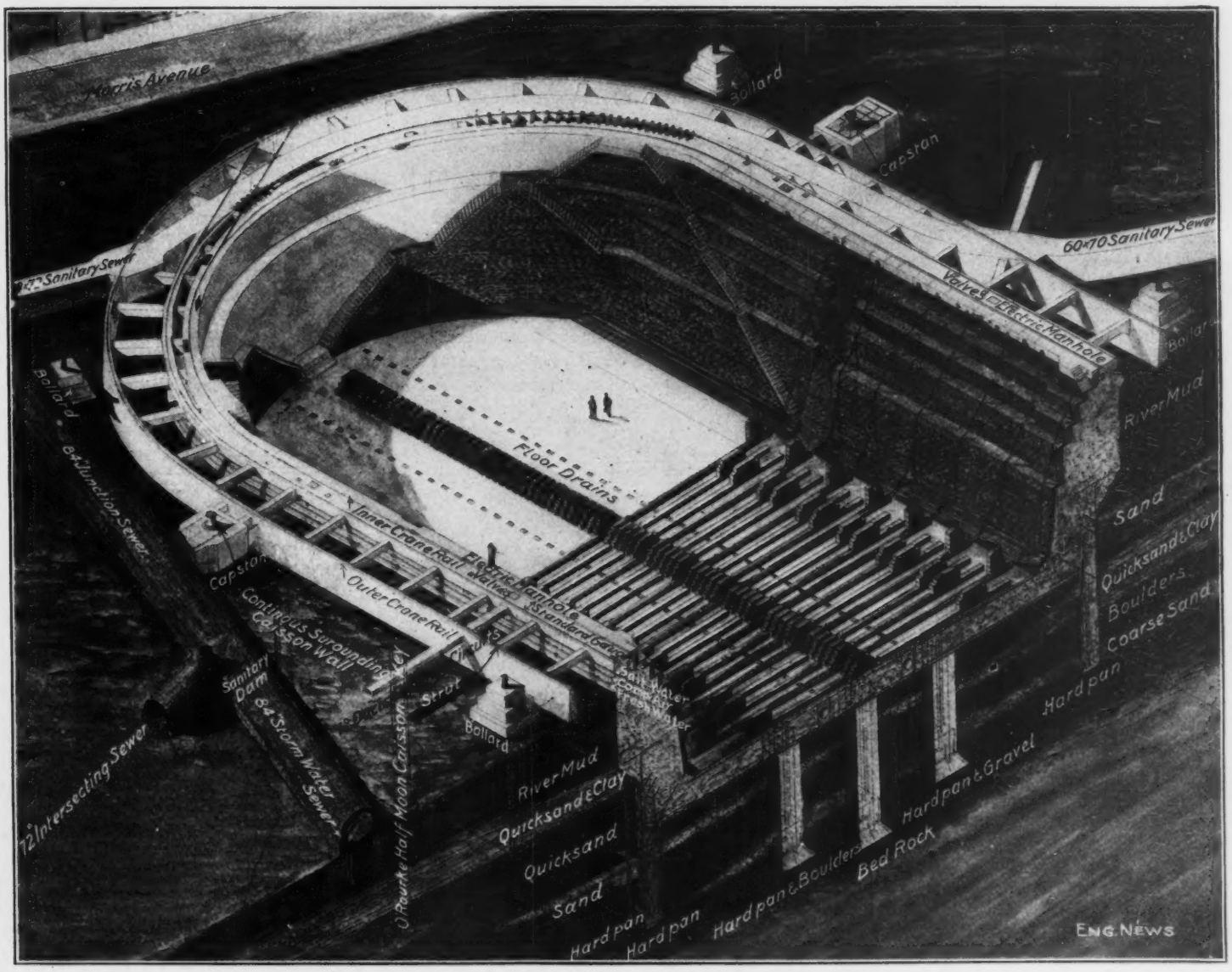


FIG. 1. ISOMETRIC SECTIONAL SKETCH OF HEAD PORTION OF DRY DOCK NO. 4, NEW YORK NAVY YARD

(Usable length of dock, 700 ft.; width at keel-blocks, 110 ft.; depth over sill, 36 ft. Construction authorized 1900; Dock completed 1912.)

*Chief Draftsman, New York Navy Yard, New York City.

First Contract

The first contract was awarded to Geo. B. Spearin, of Brooklyn. The history of previous dry docks constructed in the yard was apparently not studied by this contractor, and undoubtedly the difficulties of building a dock in the treacherous quicksand subsoil were not appreciated. The contractor planned to excavate the entire site as an open trench, surrounded by steel sheet-piling, presumably to be braced from the interior by shoring or struts. However, shores were not placed until considerable movement had taken place in the steel sheet-piling, which was forced inward by the pressure of the banks outside. The material, although soft enough to flow and even to rise up in the bottom of the excavation, was such that the steel sheet-piling was twisted and deflected, as was discovered later under subsequent contracts. When the excavation reached a certain depth, a large sewer at the head of the dry dock collapsed, and the soil settled and moved laterally.

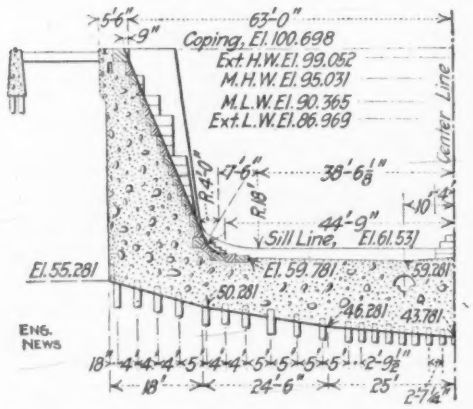


Fig. 2. Original Gravity Design of Dry Dock No. 4, New York Navy Yard, as Enlarged during Second Contract

During subsequent work it was necessary to remove all the steel sheet-piling driven by this contractor within the area inclosed by the foundation walls. Much of it had to be cut with the oxyacetylene torch, as it was impossible to pull it.

Second Contract

The contractor eventually got to the point where he was making no progress, and on Apr. 14, 1908, his contract was forfeited and it was re-let to the Williams Engineering-Contracting Co. This contractor adopted the English method of building the side walls in open trench, with braced sheeting.

The progress made by the Williams company became unsatisfactory after work had been in progress for about a year, and the contract was forfeited on Oct. 1, 1909. The total of the work done by this company was, roughly: Some slight addition to the excavation made by Spearin, the driving of foundation piles over a small area, and the placing of about 2500 cu.yd. of mass concrete on the piles. The work was repeatedly flooded, and the retained material pushed the sheeting toward the center of the excavation.

During this contract the dimensions and section of the dock had been changed to the following: Length over all, 620 ft. (in place of 563 ft.); width in body of dock at coping, 126 ft. (in place of 130 ft.); depth over sill at mean high water, 33 ft. (in place of 31 ft.); the general type of construction was retained. A typical cross-section of the dock under the revised plan is shown in Fig. 2.

Inviting New Bids

The contract for the dry dock stated that in case of failure of the contractor to complete the work, it could be taken over by the Government and completed under the jurisdiction of the Secretary of the Navy. Nine years had elapsed since the appropriation was made, and the Navy Department was confronted with the situation of having warships in commission of such size that they could not be drydocked in any of the then existing Government drydocks. Consideration was given to completing the structure by Government labor, but it was finally decided to invite bids on the work from five contractors of tried financial ability and experience. While such practice is not unusual outside of Government work, this is believed to be the first occasion upon which the method was employed by the United States Government.

Bids were asked from the following: O'Rourke Engineering-Contracting Co., New York; S. Pearson & Son, New York; The Foundation Company, New York; The Degnon Contracting Co., New York, and Holbrook, Cabot & Rollins Corporation, Boston, Mass. The last named company was the lowest bidder, its bid being $1,389,000.

Third Contract, with Contingent Feature

There were insufficient funds remaining available to permit of accepting the lowest bid, and a further precedent was established in Government work. In November, 1909, a contract was entered into with the lowest bidder on a basis of cost plus 10%, the Navy Department reserving the right to accept the lump-sum bid when Congress had authorized sufficient funds to permit of such a course. On Sept. 1, 1910, additional funds having been appropriated, a lump-sum contract was entered into, opportunity being taken to incorporate into this contract provision for increase in the dimensions

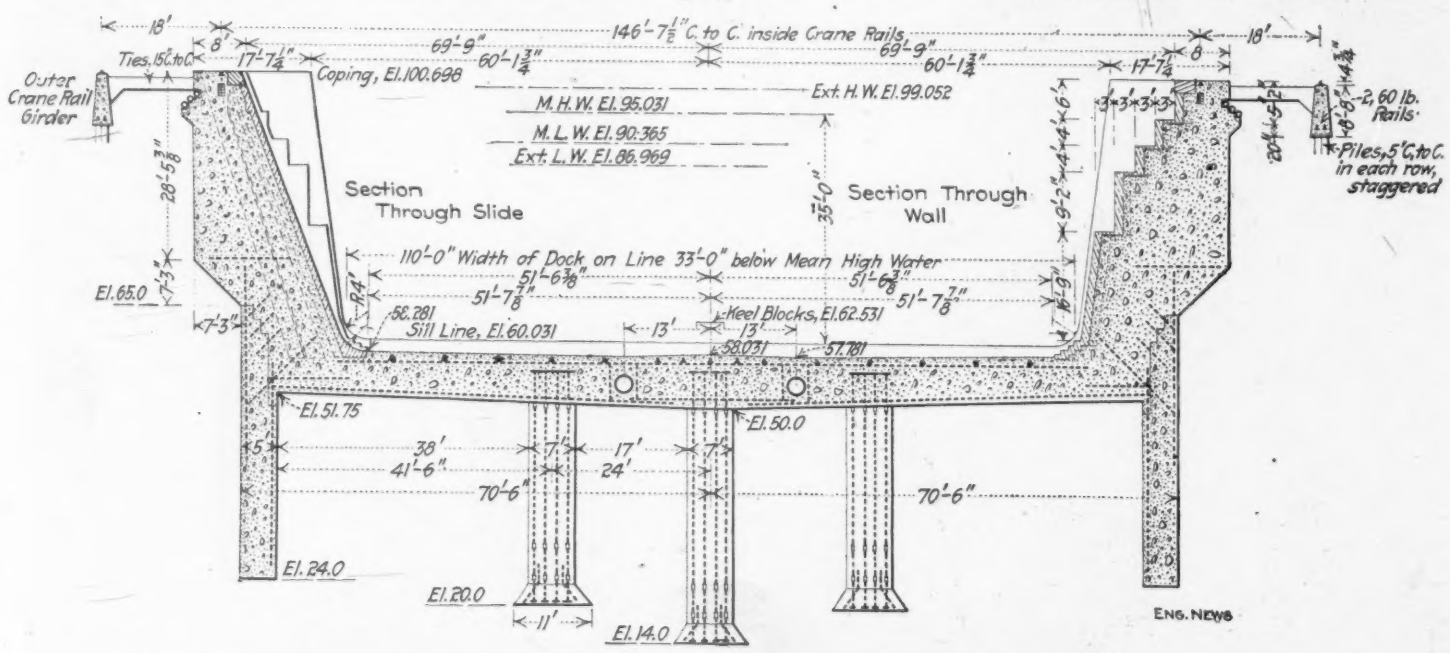


Fig. 3. Caisson-Supported Reinforced-Concrete Design of Dry Dock No. 4, New York Navy Yard, as Built under Third Contract

of the dock, and an entire change in the type of construction proposed, as referred to farther below.

Preliminary Examination of Site

Test borings had been made over the site during the first contract, by the contractor. They were considered incomplete, and one of the first steps now was to make an entirely new set of test borings. These indicated ledge rock 101 ft. below ground at a point 100 ft. beyond the head of the dry dock, the rock shelving off toward the entrance of the dock to a considerably greater depth. It was found that the surface material on the site consisted largely of river mud, underlain by a fine quicksand, which, when wet, flowed almost as freely as water; pockets of fine and coarse sand; mixtures of sand, clay, gravel and boulders; below the boulders, as a usual thing, mixtures of fine and coarse sand in fairly well defined beds; below these, typical gravel and clay hardpan, on the bedrock.

Judging from the arrangement and order of occurrence of these materials, the soil here is glacial drift, a terminal moraine of the glaciers from the Hudson and Connecticut valleys. The location of the dry dock is near the edge of this deposit, where it is thinning out, as is shown by the location of the Wallabout Channel of the East River in the immediate neighborhood. The crest of this deposit can be traced through a ridge extending along the northwest wall of the Navy ard, thence through Brooklyn into Prospect Park, and its continuation is found in Forest Park, thence going eastward along Long Island.

Plan of Work

In view of the experience of the previous contractors in inclosing the site with sheet-piling (steel sheet-piling being used by Spearin, and 10-in. and 12-in. wooden sheet-piling by the Williams company), the contractors proposed substituting for this sheet-piling concrete caissons sunk under compressed air. The caissons were to take the place of 12-in. wooden sheet-piling called for in the contract and of the outer two rows of bearing piles.

This general plan of work was adhered to, and under it the work was carried to successful conclusion. The details of the dock and the functions of the caissons were considerably altered, however, when the size and design of the dock were changed during the execution of the contract.

On account of the difficulty encountered in the construction of the dock under previous contract, and the urgent need for the completed structure, the Assistant Secretary of the Navy, Hon. Beekman Winthrop, personally took charge of the arrangements for the completion of the work and detailed Mr. Frederic R. Harris, of the Corps of Civil Engineers, U. S. Navy, then stationed at the Bureau of Yards and Docks in Washington, to New York to supervise the construction, with a special office and organization independent of the regular yard engineering work.

Change to Reinforced-concrete Type

It was early realized that the massive gravity floor required a depth of excavation which could be very largely reduced by the adoption of a reinforced-concrete floor. The instability of the bottom material, which had been fully manifest in the two earlier contracts, made it desirable to reduce the depth of excavation as much as possible. Mr. Harris, therefore, designed a reinforced-concrete floor supported by a center line of caisson columns in addition to the side-wall caissons. This design was accepted by the contractor without change of contract price.

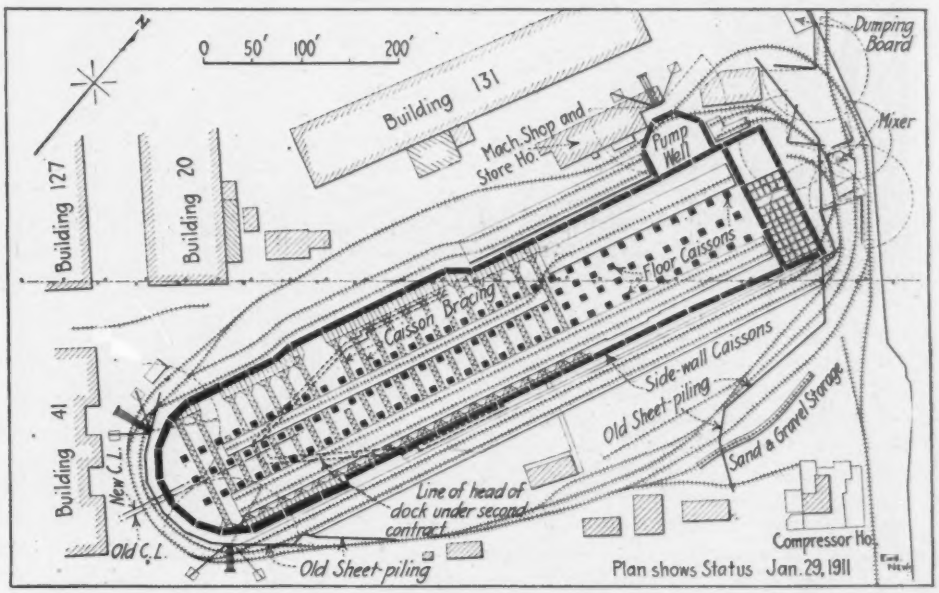


Fig. 4. Caisson Plan, Showing Also Part of Bracing; Dry Dock No. 4, New York Navy Yard

(The dotted lines show the outline of the dock on which the third contract was let. The full heavy line is the steel sheet-piling driven under an earlier contract.)

Within a short time, however, it became evident that the advances in the size of warships, and the dimensions fixed for the locks of the Panama Canal, made it highly desirable to increase the size of the dry dock over the dimensions previously fixed, so that it would be capable of taking the largest ship of the Navy and the widest ship that the Panama Canal will accommodate. Such widening required the center line of the dock to be shifted some 8 ft. The project was ultimately approved by the Navy Department, and on the basis of the revised lump-sum bid it was carried into execution by the contractor.

As some of the center-line caissons planned for under the reinforced-concrete design had already been started, these were left unchanged, giving rise to a slight irregularity in the caisson plan (see Fig. 4).

Final Design of Enlarged Dock

The dimensions of the dock as finally planned and as constructed are: Length over all, 723 ft.; available length from head to outer sill, 700 ft.; width at coping, 139 ft. 6 in.; at keel blocks at entrance, 110 ft.; depth over sill at mean high water, 36 ft.; depth from floor to coping in body of dock, 42 ft. 8 in. on center line, 42 ft. 11 in. at low point over drains, and 42 ft. 5 in. at foot of lowest altar. A comparison of Figs. 2 and 3 shows the relative sizes of the dock as enlarged under the Williams contract and the dock as finally constructed, and also gives a comparison of the types of design.

The design utilizes the caisson wall, proposed by the contractor to inclose the site, for a part of the completed structure. The caisson wall is, therefore, reinforced with steel for anchorage and bonded to the side walls above the floor. These caissons, instead of being placed flush with the outer faces of the side walls as originally proposed by the contractor, are approximately central under the walls and the walls overhang outward, as the section Fig. 3 shows. The floor of the dock is a flat reinforced-concrete slab 8 ft. thick, resting on three longitudinal lines of caisson columns between the side-wall caissons. The interior caissons are so constructed as to serve as anchorage for the floor against upward hydrostatic pressure.

The adopted plan has the following features of advantage when compared with the original plan: The depth of excavation is materially decreased, and to this extent the quicksand soil blanket on top of the water-bearing coarse sands and gravel remains undisturbed. The method of construction by the inclosing wall of caissons made it possible to

lengthen the dock landward 100 ft. without endangering the near-by buildings of the yard.

Preparing for Caisson Sinking

Four lines of standard-gage track on trestle were constructed parallel to the center line of the dock in the pit, at approximately the level of the yard, to carry eight 15-ton locomotive cranes, which were to handle the excavation and the supply of materials to the caisson. The ground outside of the neat lines of the dock was excavated on a slope by steam shovel, as far as conditions would permit. The plan was to start the caissons at the lowest elevation obtainable without penetrating into unstable soil or disturbing the equilibrium of the surrounding material. At the head of the dock this sloping of the ground could not be done, however, on account of the presence of existing structures; at this point, therefore, caisson sinking was started about 15 ft. below the surface, or El. 85 (ground level of the yard is about 100). At the entrance to the dock, caisson sinking was also started at a high elevation, on account of the proximity to the Wallabout Channel.

The steam shovel loaded directly to dump cars. The material from the interior of the dock excavation and the muck coming out of the caisson air-locks were handled by locomotive cranes, loaded into dump cars hauled by narrow-gage locomotives, and dumped into scows at the waterfront.

A concrete plant was erected near the waterfront, comprising a 2-yd. and a 1-yd. mixer, served by bins and derricks.

A low-pressure air-compressing plant was installed, with pipe distribution to the various caisson locations.

Caisson Construction

Two types of air lock were used in the caisson work, the Barr pot-lid lock and the Mattson side-door lock.

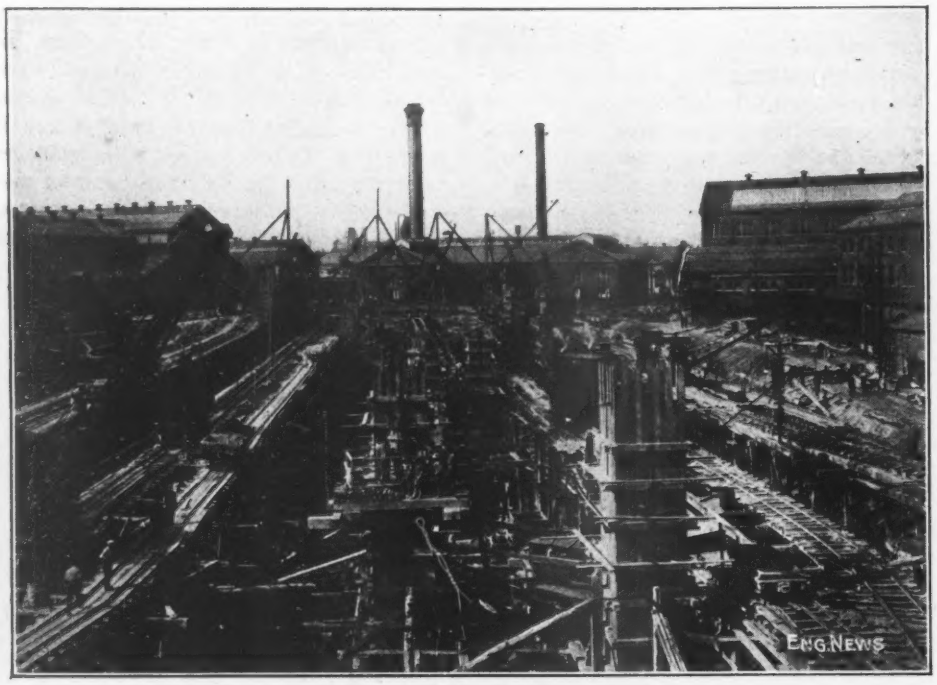


Fig. 5. Caisson Sinking in Progress at Site of Dry Dock No. 4 New York Navy Yard; July 27, 1910

The caissons were built of 2-in. tongue-and-grooved lagging on a timber frame which was a continuation of the airtight working chamber. The working chamber was 6 ft. high. The space between lagging and air shaft was filled with concrete, reinforced with steel rods, as the sinking progressed. The lagging was built up with broken joints, and was always kept well above ground.

From an early stage of the caisson sinking it became necessary to use pig-iron loading to assist in sinking the caisson, as the concrete could not be carried far enough above ground to give sufficient weight for this purpose. In one case 1400 tons of iron were used on one caisson.

The sidewall caissons were 36 ft. long and 5 ft. wide, except at the head and entrance. At the head, where the caissons were placed in a semicircle, they were 28x7 ft. (variable); at the entrance the caissons were 6 ft. wide; those across the entrance were 7 ft. wide. Each caisson of the entire inclosing ring was built with a half-moon vertical groove for key at each end. The wells thus formed at the joints between the two abutting caissons were subsequently sealed with a concrete key placed under air pressure. These keys were for most of the work 3 ft. in diameter, but in the arch caissons around the head of the dock they were 5 ft., to keep the line of arch thrust in solid concrete.

Concrete for the caissons was delivered from the mixing plant by dump buckets carried on flat cars on the trestle tracks, and handled by the locomotive cranes.

The side-wall caissons were recessed 12 in. deep on the inner side to provide for bonding in the floor of the drydock, and at the top were stepped off to bond into the side wall. Reinforcing rods were imbedded in the caisson concrete as shown in Fig. 3, the diagonal rods being bent up inside the forms and later on bent out, with the use of blow torches for heating the rods.

The caissons were in all cases carried up to just above the surrounding ground level. Where, as at the head of the dock, the caissons were built higher than the beginning of the outer wall slope (Fig. 3), vertical dovetailed key slots with pro-

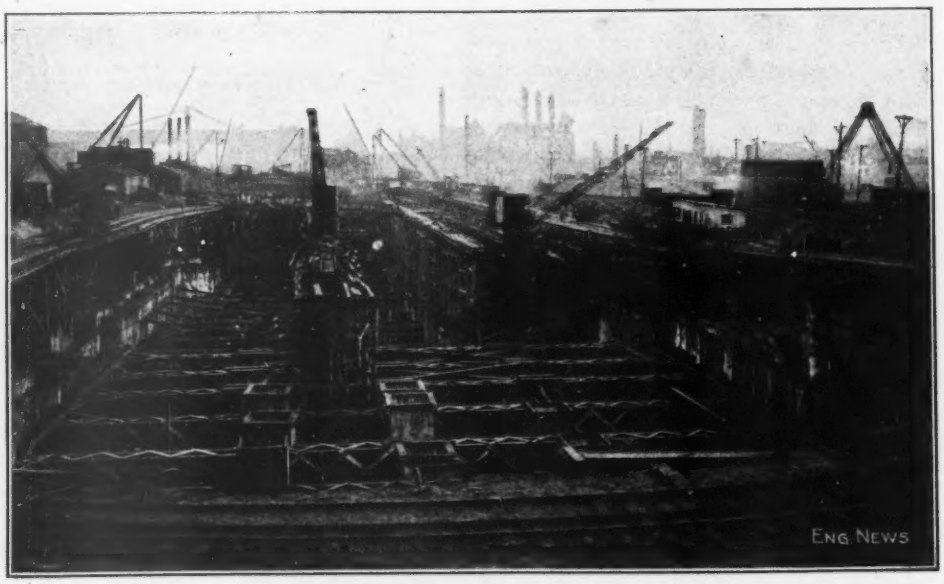


Fig. 6. Bracing of Sidewall Caissons, Dry Dock No. 4, New York Navy Yard; Jan. 31, 1911

(The crane trestles are being removed for placing the second tier of bracing.)

jecting reinforcement were molded in the caissons for bond.

The side-wall caissons were required to be sunk to a depth of 77 ft. below coping level as a minimum, with a view to securing an effective cutoff wall, and to extend below the general level of strata. At the same time the contractor was required to carry each caisson down to firm bearing strata, and the caissons were actually in nearly all cases sunk considerably below the minimum depth. At the head of the dock the caissons were sunk to ledge rock; elsewhere they rest on gravel or hardpan.

On the west side of the dock for a distance of 174 ft., it was necessary to sink the caissons approximately 10 ft. outside of the general line of the inclosing caisson, because of interference by old steel sheet piling. The continuity of the line of caissons was preserved by sinking two caissons at an angle, as shown in Fig. 4. On the east side a similar condition was handled by lapping one caisson past the next one.

Interior Caisson Columns

The floor of the dock is supported by three longitudinal lines of concrete columns 7-ft. square, sunk as caissons, 100 in all. They are spaced 24 ft. c. to c. transversely, and 20 ft. c. to c. longitudinally. They are reinforced by eight 2¼-in. rods in the concrete around the air shaft, and two 3-in. rods placed in the air shaft when concreting this (these figures apply to the center-line caissons). The reinforcement extends 6 ft. into the floor of the dock. The foot of each caisson is belled out to 11 ft. square in order to give a broader bearing area and also for additional anchorage against uplift. This flaring out was done by driving poling boards from the cutting-edge when the proper level had been reached. Inclined reinforcing rods were placed along the faces of the belled portion.

The interior caissons were required to be sunk to a minimum depth of 87 ft. for the center line and 81 ft. for the two side lines. This minimum depth was determined by anchorage requirements. The caissons were further required to penetrate the quicksand soils and rest on stable material; actually they were in nearly all cases sunk below the minimum depth.

Caisson sinking was carried on continuously. The sand hogs worked 4-hr. shifts when conditions permitted and 2-hr. shifts under extreme conditions. Fig. 5 gives a general view of the work looking from the entrance of the dock toward the head, during the caisson sinking.

In the course of the caisson work it was necessary to remove almost the entire quantity of steel sheet-piling within the outlines of the dock and approximately 2500 cu.yd. of concrete left in place by the Williams company.

Sewer Relocation

In connection with this stage of the work it was necessary to change the location of a 6-ft. sewer, which served the Borough of Brooklyn, passing through the area occupied by the dock, and draining a large area adjacent to the Navy Yard. This sewer, originally a brick arch with segmental invert, was rebuilt of reinforced concrete in rectangular cross-section 5 ft. by 6 ft., supported by two rows of piles. It was located on a line closely following the outside of the dock wall and encircling the head of the dock.

In order to secure the flow of sanitary drainage through this sewer, it was necessary to reverse the flow in part of a 7-ft. sewer intersecting the 6-ft. sewer. This was successfully done. At present sanitary discharge is being carried around the head of the dock to a point some 4500 ft. distant, at the northwest corner of the Navy Yard. This obviates any nuisance to the neighborhood of the docks from sewer discharge. The old sewer outfall into the yard basin is retained as a storm-water relief.

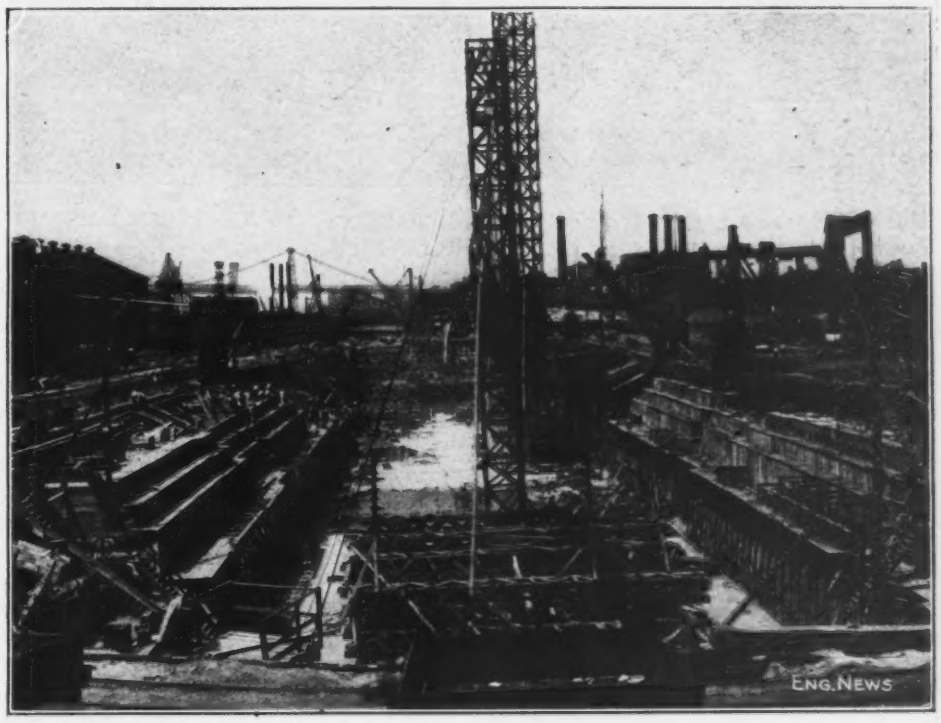


Fig. 7. View of Sidewall Construction, Dry Dock No. 4, New York Navy Yard; July 31, 1911.

(View looking north toward entrance, as in Fig. 6; Fig. 5 is a view looking south from entrance toward head.)

Floor of Dock

As already noted, the floor of the dock is a reinforced-concrete slab 8 ft. thick. Its upper surface is level longitudinally, but transversely it is graded down to the longitudinal drains, 13 ft. either side of the center.

The floor is reinforced by transverse lines of railway rails and rods, located centrally over the transverse rows of caisson columns. Each group contains 58 sq.in. of steel. These groups are 20 ft. apart. The reinforcement consists partly of second-hand 100-lb. rails, and partly of 2-in. twisted steel rods, all being 60 ft. long, extending from the side walls to within a few feet of the center, and spliced across the center by an equivalent cross-sectional area, with sufficient lap to develop the maximum capacity of the bars. There is also a system of upper reinforcement, consisting of seven 110-lb. rails transversely over each line of caissons, and 18 longitudinal lines of 60-lb. rails lapped 7 ft. 6 in. at each joint to develop the stress, and 24 longitudinal 1-in. square twisted rods 2 ft. 8 in. on centers, between the rails.

The floor concrete was put in in alternate sections, so as to leave unexcavated and braced spaces undisturbed and avoid opening up too large an area of floor. It was intended to make the sections 20 ft. wide, centrally over a transverse row of floor caissons, but it proved possible to open wider sections, and in one instance a section 48 ft. wide, containing 1640 cu.yd., was laid in one operation, this concrete being placed in 26 hours.

Before the floor work was started excavation had been carried on at intervals of 20 ft. close enough to subgrade to permit the placing of latticed timber struts for bracing the upper part of the side-wall caissons against the thrust of the bank outside. Fig. 6 illustrates this bracing.

Concrete for the floor was delivered by 2-yd. hopper cars running on a narrow-gage track encircling the dock, to chutes placed at intervals along the side, which

allowed the concrete to flow by gravity to the floor of the dock, where it could be tapped off by openings in the chutes wherever required. Each section of floor was finished from wall to wall until a large portion of this floor, in gridiron fashion, was in place. Then the bracing

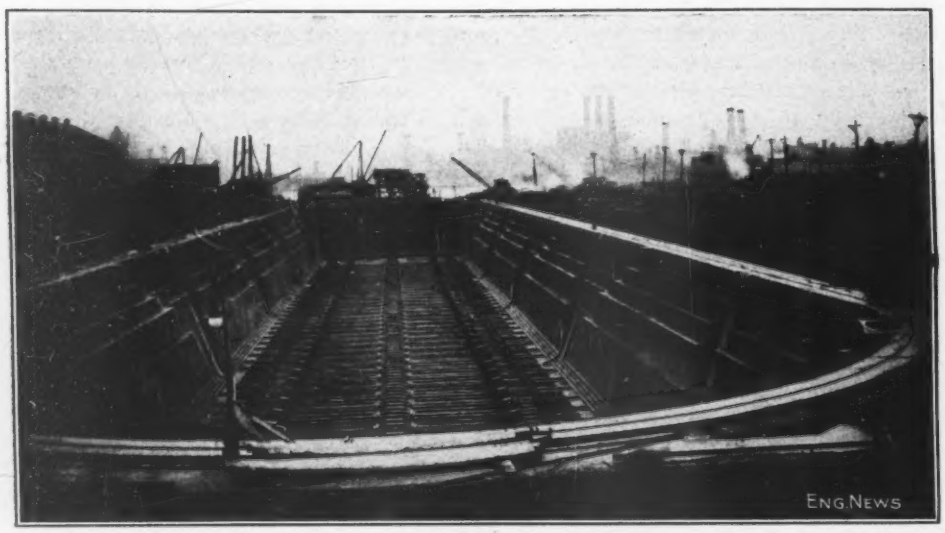


FIG. 8. DRY DOCK NO. 4, NEW YORK NAVY YARD, COMPLETED EXCEPT FOR ERECTION OF GATE; DEC. 15, 1911

was removed, the intermediate portions of the floor placed and finished, and the whole floor brought to a general finish.

SIDE WALL CONSTRUCTION AND LINING

The walls of the dock are faced with vitrified brick, except that the copings, caisson-gate seats, and abutments, are of granite. At the head above the stair line the face is of concrete troweled to a smooth finish; this face is reinforced over its entire area by a gridiron of ½-in. square twisted rods, 18-in. c. to c. horizontally and vertically, tied back to ¾-in. square twisted rods, set at an angle of 45°, embedded in the caissons supporting this wall. The walls were built by carrying up the vitrified brick facing in steps and backing it up with the mass concrete which forms the body of the wall.

Some of the wall concrete was placed by the G-Y system of tower distribution, but this method was found to be very poorly adapted to this particular work; it is doubtful if a much greater quantity than 500 cu.yd. was placed by this method before it was discarded. The bulk of the concrete backing was put in place from hopper cars just as the floor concrete.

At the back of the wall at the top are formed ledges to support supply lines, and in the upper part of the wall was embedded a bank of electric-wire ducts. Steel tie-bars projecting out from the upper part of the wall were built into the concrete at intervals of 15 ft. to form the reinforcement of struts tying the crane-track supports to the dock itself.

TRACK AND SUPPLY LINES

CRANE TRACK—The dock is encircled by a crane track of 100-lb. rail. The inner rail is supported directly on the wall of the dock, and the outer rail is placed at 18 ft. gage on a special concrete girder supported on piles. In cross-section this girder is a trapezoid 8 ft. 8 in. deep, 3 ft. wide at the bottom, and 1 ft. 6 in. wide at the top. It is reinforced by two 60-lb. rails laid just above the piles, with proper laps. The crane support is tied to the concrete wall of the dock by reinforced-concrete struts, 2 ft. by 1 ft. 6 in. in section, placed about 15 ft. apart.

This track is intended for the use of 40-ton cranes of 18-ft. gage, now in use for the dry docks and waterfront service of the yard. The track is connected by turnouts and connecting tracks with the crane tracks of the other docks, so that the cranes can be moved from one dock to the other.

At standard gage (4 ft. 8½ in.) from the inside crane rail, a 60-lb. rail is laid in the concrete of the coping, following the crane rail entirely around the dock, thus permitting the use of standard-gage locomotive cranes or other rolling stock on the coping of the dock.

A ¼-in. link chain, supported on removable steel stanchions set in sockets in the coping stone, is provided around the coping as a railing.

SUPPLY PIPING—Pipe lines 6 in. in diameter, carrying salt water, fresh water, and compressed air, are supported on ledges formed on the back of the dock wall near the top against the fill. This allows the pipe to be excavated from outside in case of necessity, while keeping the lines below frost level. At frequent intervals the pipes are branched to deliver their supplies to the face of the dock wall on the upper altar, where connections can be made to them from the interior of the dock by opening a cast-iron door flush with the dock wall. The valve stems on these branches are reached by a key from the coping. One connection of this kind is furnished at the center line at the head of the dock, and 22 other groups of connections occur at regular intervals along the side walls.

Electric-power supply to the various points where required is obtained from a vitrified 8-hole duct built into the dock wall near the top. Connections are taken off from this duct through a 3-in. pipe to the motors in the capstan pits. The high-tension cables supplying 2300-volt alternating current to the pump well are also carried in this duct. Manhole chambers 5 ft. by 3 ft., with 18x25-in. manholes in the coping, are provided in the main duct lines at about 60-ft. intervals, and provision is also made to take off at these points leads which are carried through the walls of the dock to watertight outlet boxes situated near the bottom of the wall, and at a point on the face accessible to the fifth altar.

The transformers for the 230-volt circuit of the capstan motors are located near the center-line capstan in a wing of the central power plant, at the head of the dock.

CONSTRUCTION OF ENTRANCE OF DOCK

Several methods of holding the material at the front of the dock during the construction of the entrance were discussed. It was finally decided to sink two lines of caissons across the entrance in such location and arrangement that their upper continuation could be used as a coffer-dam. Within this coffer-dam the two granite sills for the caisson gate, 25 ft. apart, and the floor between them would be constructed. This plan was carried out successfully.

As the location of the outer caisson for this work was about 90 ft. from the sea wall, a considerable portion of the earth and water thrust was dissipated by the earth left in place; the earth behind the interior coffer-dam face was also left in position for a considerable distance, and the bracing in the coffer-dam transmitted the thrust across from wall to wall of the dam. Construction within the coffer-

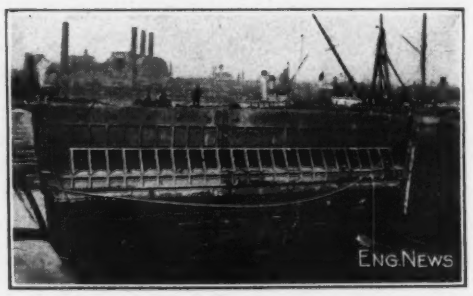


FIG. 9. CAISSON GATE OF DRY DOCK NO. 4, NEW YORK NAVY YARD; MAY 1, 1912

dam was carried on without serious difficulty and the floor and sills were built complete before the floor of the interior of the dock near the entrance was constructed. Then the outer face of the coffer-dam was braced by raking struts

butting against the sills, and thereafter the interior coffer-dam face and the earth behind it were removed and the remainder of the dock floor built.

Following the completion of the body of the dock, the dock was flooded, the entrance dredged, and the coffer-dam removed. Then the caisson gate, which had been assembled at Norfolk, Va., was floated into place.

Stairs and Material Slides

There are 14 complete flights of stairs in the side walls of the dock. In order to introduce these stairs without projection, the altars were reduced from the standard width of 3 ft. to 2 ft. 6 in. where necessary, and were recessed so as to take up the difference of width in the height of the side walls. The stairs are of reinforced concrete, with Wainwright nosings.

Ten material slides are built into the side walls, 5 on each side. They are 6 ft. wide, with the exception of one on the west side of the dock near the head, which has been made 8 ft. wide for the possible installation of an elevator to handle men and material. The slides are faced with brick of the same kind as used in the side-wall facing.

Each slide acts as an expansion joint. The material for the body of the side wall was placed and allowed to set before the concrete and brick of the slide portion were built. The joint between the abutting surfaces is made with burlap and tar, and percolation of water through the joints was forestalled by setting in a folded sheet of lead which can open and close as the walls draw apart or come together, without permitting the passage of water.

Blocks and Bearers

The entire floor of the dock to a point within 8 ft. of the beginning of the stairs at the head is supplied with oak keel-blocks set transversely, 2 ft. apart, anchored to the concrete floor. From a point opposite material slide No. 1 to a point just beyond slide No. 9, near the head of the dock, docking keel-blocks and bilge-block bearers are placed at intervals of 4 ft. As this blocking extends almost from side to side of the dock floor with very little interruption, a cast-iron drain cover is placed at intervals of 4 ft. over each of the drain culverts, allowing for the rapid discharge of the water impounded below the level of the blocking. The main body of the water in the dock is drained to the pump directly through inlets in the side walls.

Suitable operating devices for the bilge-block bearers are provided as usual.

Gate and Approaches

The dimensions of the caisson gate are: Length over all, 123 ft. 7⅞ in.; beam on waterline, 20 ft.; width on dock, 15 ft.; total depth, 42 ft. 3¼ in.; draft when floating, 22 ft. 6 in. A keel extends entirely around the structure from deck to deck line; it is 2 ft. 6½ in. wide back to back of angles, and is flanked by two 15-in. 55-lb. channels with flanges turned out, carrying 6 in. of oak on each side. In a groove of these oak facing strips a rubber gasket is fitted, a total of 392 lin.ft. This permits the setting of the caisson with either side toward the dock. The cross-section of the caisson gate is reduced by a sharp right-angled deck recess about 27½ ft. above the keel; the hull above this point is 8 ft. wide. As the caisson gate sinks, this deck becoming submerged adds the weight of the overflowing water to assist the sinking of the caisson into position. The lower part of the hull is filled with concrete sufficient to keep the gate on an even keel when afloat. It is equipped with sea valves through which the water can be admitted both to the caisson hull and to the dock. Motor-driven pumps are provided for the purpose of discharging the water admitted to the hull after it has been used for the purpose of sinking the caisson into place.

A standard-gage railroad track crosses the gate longitudinally, connecting with tracks on the coping of the dock; this allows the passage of rolling stock across the mouth of the dock, eliminating about 1500 ft. of travel to reach the opposite side of the dock at the water front.

Each caisson seat is provided with a recess in which is mounted a swinging bolt engaging a jaw on the center line of the caisson at each end. This permits the caisson to be locked into position after being sunk to its seat.

The gate is shown by the view Fig. 9.

The approach to the entrance from the sea wall to the outer gate sill is about 90 ft. long. This distance was dredged and an approach wall of concrete faced with granite was built on a low-water pile platform along each side.

Equipment of Dock

Pump Well—The pump well is located on the northwest side of the dock near the entrance. It is an inclosure formed by sinking caissons in the shape of five sides of an octagon, the dock wall supplying the place of the missing sides. It is 51 ft. long inside and 28 ft. wide at right angles to the center line of the dock. The drainage of the dock enters the pumps from a forebay in a compartment of the pump well, by three tunnels 6x6 ft. in cross-section with three 6x16-ft. drain openings in the floor of the dock. The pumps discharge into a chamber immediately above the forebay, and thence the water passes out through a discharge culvert leading to the waterfront. This culvert is 10 ft. in minimum width and 15½ ft. high to mean high-water line.

The two longitudinal drain culverts under the floor, extending the entire length of the dock, vary from 2 ft. to 3 ft. in diameter, the farther 195 ft. being of the smaller size. They discharge into the pits below the drain openings mentioned above. The openings in the floor are located just in front of the pump well, and are covered by gratings of 3x¾-in. bars 1½ in. on centers.

The pumping equipment comprises three vertical-shaft centrifugal pumps

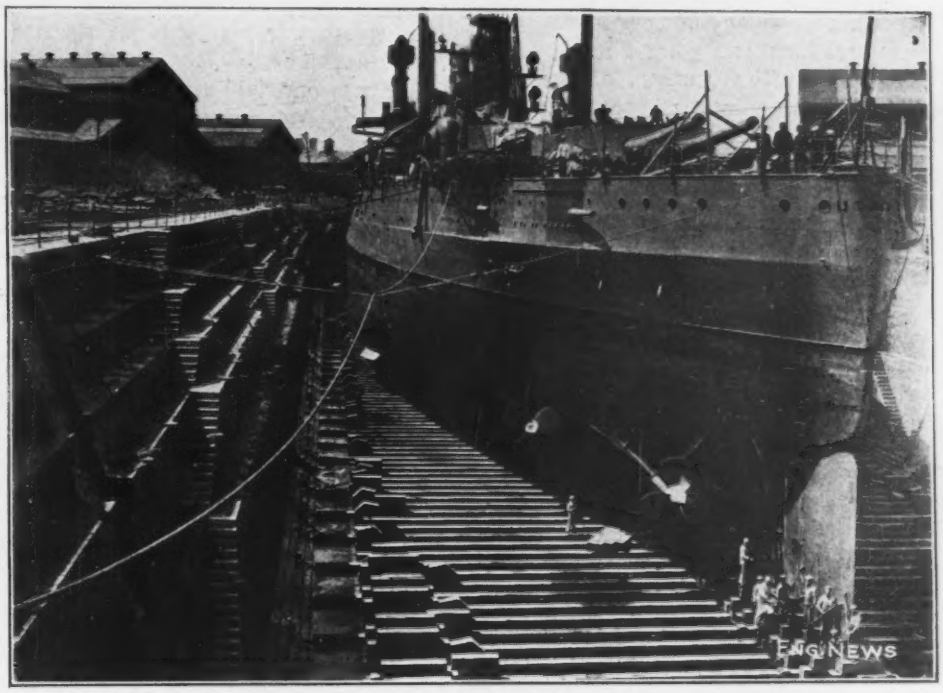


Fig. 10. Battleship "Utah" in Dry Dock No. 4, New York Navy Yard; May 10, 1912

(The first docking in the new dry dock. The "Utah" is the largest war vessel of the U. S. Navy.)

with 54-in. intake and 48-in. discharge, having a maximum possible lift of 13.33 ft. and discharging against a head varying from 23.64 to 35.72 ft. They are driven by 500-hp. alternating-current induction motors (60-cycle, 3-phase, 32-pole) running at a speed of 217 to 225 r.p.m.

Two smaller pumps, 15 in. in diameter, are provided for handling the floor drainage. They are driven by 85-hp. induction motors running at 600 r.p.m. (12-pole, 60-cycle, 3-phase). Instead of discharging into the main culvert, these smaller pumps discharge into a 20-in. cast-iron pipe.

A 2-in. pump for the sump well is also provided. This is driven by a small motor fed from the secondary switchboard.

The pumps were required to discharge not less than 8800 cu.ft. per minute each from zero head to a point 1 ft. above the keel-blocks. The contents of the dock between these points is about 22,000,000 gal., or 2,940,000 cu.ft.

Each of the larger pumps is controlled through a panel-board equipped with starting resistance, oil switch, ammeter, and overload and no-voltage releases. The 15-in. pump motors are controlled by similar panels, having, however, a starting compensator instead of a resistance. The motors also have relays controlled by pressure regulators on the oil system to shut down the motors in case the oil pressure fails.

A secondary switchboard governs the oil pumps, valves, ventilating fan, sump pump, air compressor, and hydraulic pump for supplying the sluice gates.

The sluice gates for flooding the dock are connected to the discharge culvert and are operated by city-water pressure.

In connection with the pumping equipment a 48-in. cast-iron suction and discharge pipe for the condensing system of the yard power plant was installed, with intake well at the seawall, fitted with screens and valves. The discharge line opens into the discharge chamber of the pump well. This pipe is controlled at either end by hand-operated geared gate-valves. The land end of the suction line discharges into a suction well sunk near the head of the dock outside of the power house, whence the power-house supply is drawn. The discharge main connects directly with the condenser system in the power house. Both intake and suction wells were put down by means of caissons.

Capstans and Bollards

On account of the yard street at the head of the dry dock, it was impossible to place the center-line capstan in the open. The capstan and its handling apparatus were placed in a portion of the first floor of the east wing of the yard power plant. Six other capstans were provided, two located on the entrance walls at the entrance of the dock, two approximately in the middle of the sides and two others on the shoulders of the semicircular head.

At intermediate points between capstans, 19 bollards made of old guns, set in concrete blocks, were provided. Cleats were fitted at various points on the coping and small winches and other necessary appliances for handling docking and keel-blocks are provided at the proper positions.

Direction and Execution of Work

The construction of the dry dock was done under the Bureau of Yards and Docks of the Navy Department. F. R. Harris, Corps of Civil Engineers, U. S. Navy, was the designing and supervising engineer. Up to April, 1911, H. L. Muchemore was his principal assistant; from that time to the present, W. T. Gould was principal assistant.

The dry dock was constructed by the Holbrook, Cabot & Rollins Corporation, Boston, Mass. Fred Holbrook, General Manager of this corporation, was in charge, Thos. B. Bryson designed and directed the caisson work, and G. H. Clark was engineer to the corporation. The caisson gate was built by the Penn Bridge Co. The pumping plant was furnished by the Alberger Pump Co., for whom Geo. Symonds was in charge of the erection. The capstans were furnished by the American Engineering Co.

A Pontoon Bridge with Submerged pontoons has been designed for a crossing of the Hoogly River at Calcutta, India, by Head, Wrightson & Co., Ltd., of Stockton-on-Tees, England, for a competition called by the Calcutta Port Trust, to replace the existing pontoon bridge (built in 1874). The design is described in "The Engineer" (London), June 28, 1912. The pontoons are about 15½ ft. in diameter by 220 ft. long, transverse to the bridge. Their number and spacing is such that the full load (dead and live) of the bridge is less than the buoyancy of the pontoons. They are held with top about 2 ft. below low-water surface by 4-in. vertical anchor rods with adjusting screws attached to loaded cylinders sunk to the river bottom as anchorage. The river has a range of about 20 ft. The bridge trusses are supported on the submerged pontoons by supports which give the bridge a fixed level. A pontoon bridge is required because the river bottom offers no opportunity for fixed piers, and the ebb and flow of the river are likely to produce an injurious amount of scour.

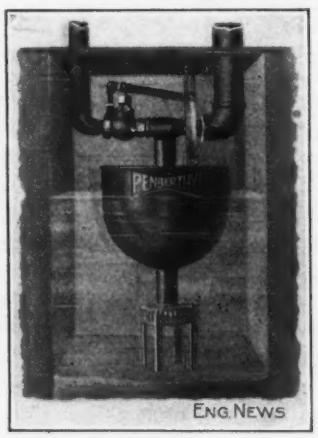
The bridge has a channel opening consisting of bobtail swing-spans supported on the adjacent portions of the pontoon bridge. The bridge is fixed transversely by anchorage cables extending upstream and downstream.

The submerged pontoon system is stated to be invented by F. Forssell, whose patents in the entire British Empire are owned by Head, Wrightson & Co. A floating pontoon bridge has also been designed by the company for the same location.

An Automatic Sump Ejector

The accompanying illustration shows a simple, automatic ejector for draining cellars or sumps.

The device consists of a semicylindrical float, adjustable for any depth of water in the sump, and operating a quick opening valve of a water-pressure ejector.



Automatic Ejector for Draining Sumps

The chief feature of the valve-operating mechanism is the long slot in the lever arm attached to the float, which allows the sump to fill to any desired point before the valve is opened, thus avoiding the frequent opening and closing of the valve.

The float is built around the suction pipe, to make the device compact and rigid, and all workings parts with the exception of the strainer and float are above water.

This device is manufactured by the Penberthy Injector Co., of Detroit, Mich.

English Humor—The following note appears in the London "Times":

"KILLING TEREDOS WITH ELECTRICITY — A floating power plant equipped for self-propulsion has been employed on the Pacific Coast to destroy the teredo and similar marine borers that attack the submerged timber of wharves. Current is passed through the salt water, and the products of electrolysis are found to kill the teredos within a very few minutes.

"The operation is not at all complex. The wharf is first wired, and electrodes are suspended from it so as to be submerged at a greater or less depth, the details varying with local conditions. The power plant has a capacity of from 20,000 to 40,000 amperes, but the voltage is very low. The current is turned on for about an hour, and the operation is timed so that the action of the tide will help rather than hinder.

"Only the head of the borer and its worm-like body penetrate the wood, the tail remaining at the surface in contact with the water. The effect of the chlorine gas upon its soft and gelatinous structure is to coagulate it and while this electric treatment does not render the piling immune from further attack, it is claimed that an occasional treatment will keep the borers from penetrating to any great depth so that the timber can be preserved at a comparatively slight expense."

Electrolysis of Reinforced Concrete

By Harold P. Brown*

The full title of this article might be "The Prevention and Repair of Electrolytic Injury to Reinforced-Concrete Structures." It describes in detail the measures taken by Mr. Brown to stop the electrolytic action on the concrete of the Allentown packing house, described in ENGINEERING NEWS, June 8, 1911, and to repair the damage done by this action.

*Consulting Engineer, 120 Liberty St., New York City.

In the report of the American Society for Testing Materials Annual Meeting in ENGINEERING NEWS of Apr. 4, 1912, the following sentence occurs: "The report of the waterproofing committee brought about some excited discussion, during which several persons *affirmed their belief in the imperishability of concrete and protested against any hint of any other possibility.*"

It is no doubt true that many nervous or mental diseases can be cured by a practitioner who strenuously denies their existence and thus encourages the patient to resist and overcome them. But it can hardly be expected that defective concrete walls or disintegrating brick piers can be strengthened by "absent treatment," however vigorous be the denial of injury and however prominent be the denier. It is far better calmly to face the facts and when they prove to be unfavorable, to search for practical remedies and then apply them carefully. Here then are some very unwelcome facts, but with them I set forth simple remedies which I have tested for a long period and have found to be effective.

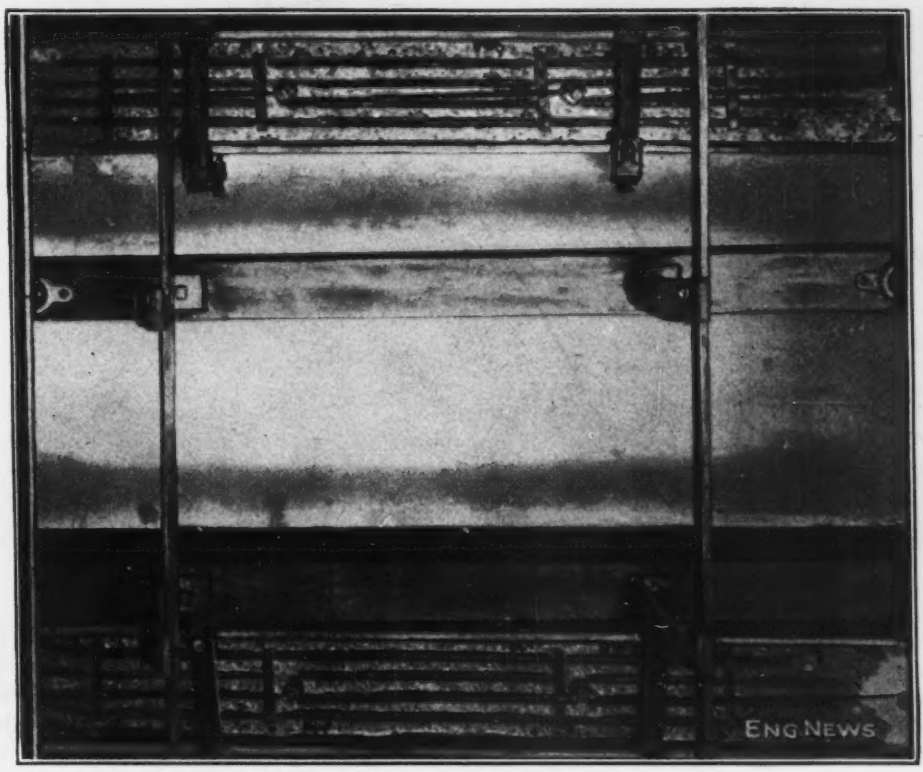


FIG. 1. EXPOSED REINFORCEMENT OF TWO CONCRETE BEAMS INJURED BY ELECTROLYSIS
(Photograph taken with camera pointing upward.)

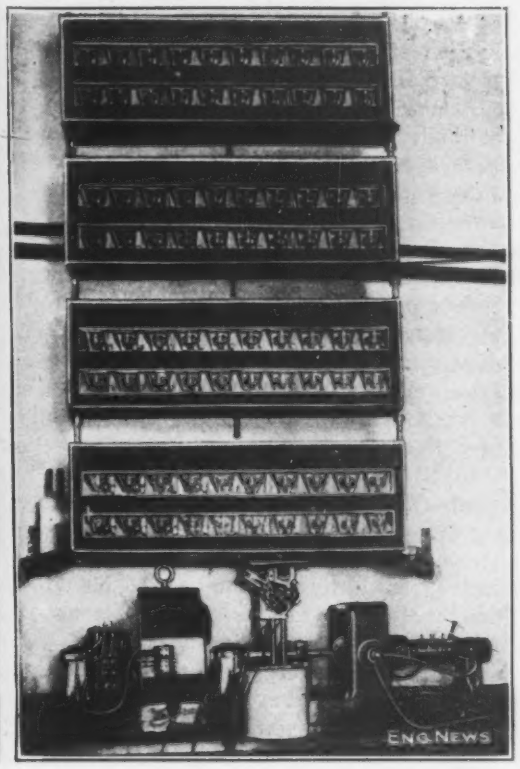


FIG. 2. TESTING DYNAMO, COMMUTATING DEVICE, CIRCUIT-BREAKERS AND ANNUNCIATORS USED FOR ELECTROLYSIS PREVENTION AT ALLENTOWN, PENN., PACKING HOUSE

1. Reinforced concrete cracks along the lines of the reinforcing rods when subjected to an electrical potential of more than 1½ volts in presence of water, even though the rods be from 5 to 6 in. from the surface. The cracks occur where the rods have a positive charge, and increase in width as long as the unfavorable conditions continue.

2. Mass concrete disintegrates in presence of water when subjected to a heavy flow of electrical current at a pressure exceeding 1½ volts. The calcium silicate and aluminum silicate are decomposed, the silicic acid appearing with the oxygen at the positive pole, while the calcium hydroxide and aluminum hydroxide are carried to the negative pole. In all cases the presence of an acid or a salt in the water hastens the destruction.

3. Structural steel and foundation bolts and plates resting on brick or concrete piers are corroded in presence of water and current flow where the charge is positive. After electrolysis has parted the bolts, continued heavy current flow in presence of leakage from gas pipes or sewers disintegrates the surrounding concrete or brick. Some kinds of limestone under the same conditions show the same results.

4. Concrete made from portland cement loses strength and crumbles when submitted to alkali-bearing waters or to sea water. The process is quickened by the application of electrical current. Great damage has already been caused on concrete wharves by current leakage from the hoisting motors. Trouble may therefore be looked for where electric motor towing cars are operated along rails carried upon concrete canal walls.

5. Brickwork, concrete made from portland cement and some kinds of limestone when used in long tunnels are disintegrated when submitted to water and dense coal smoke, even when no electrical current is indicated.

6. The fact that a concrete wall is thick enough to prevent surface dampness or the visible escape of water under pressure does not prove that it is waterproof, nor does it afford any protection from trouble when submitted to electrical current flow. Even the slight amount of

moisture held in such a wall by capillary action is sufficient to afford a conducting path to the destroying current.

7. Permanent protection from electrolysis cannot be secured by painting or by coating a concrete structure with a membrane and waterproof material. These will sooner or later hydrolize, or crack from settlement of structure, or disintegrate from action of gas liquor in the water. A leak may then occur at a long distance from the spot where the waterproof layer has failed, and destruction follow in unsuspected places.

Examples of each of these cases in large areas can be seen without going very far from the center of New York City, and effective remedies designed by me can be found in successful operation in the large reinforced-concrete packing house of the Arbogast & Bastian Co. at Allentown, Penn. This is the building whose injury by electrolysis was described in my article in ENGINEERING NEWS of June 8, 1911. In this building, as a result of electrolytic action, over 3000 lin.ft. of beams, girders and columns made of first-class concrete cracked very badly along the line of the reinforcement, and some mass concrete foundations of ammonia refrigerating coils, etc., disintegrated through the same cause. The cure of the conditions producing electrolysis and the methods used in the restoration of the structure are described in a later portion of this paper.

A very large amount of mass concrete of high quality, carefully installed in 1909 and 1910 by various railways near New York is now in magnificent shape *wherever it is dry;* it is also in fine condition where it is wet without the presence of electrical current. But wherever both water and current have reached it, the material is badly disintegrated and must soon be replaced. This also can be shown to anyone who can be trusted not to rush into the daily press with scare head lines.

In all of these cases the constructing engineers spared neither pains nor expense to obtain durable work, and the unfortunate outcome is mortifying. Some have been inclined to shift the blame onto the cement makers, but this is not justified by the facts, for had an occasional lot of poor cement been delivered, some of it would have shown up either in dry places or in wet places where there was no indication of current flow. But the concrete is fine everywhere except where it is or has been under the influence of both water and electric current.

On the other hand, some of the cement makers have tried to throw the blame on the constructors; but this is manifestly unfair, for the records show that all of the work passed careful inspection and was well done. It cannot be denied, however, that the present cement specifications permit the sale of a large amount of cement which passes the boiling test, but which shows faults after a few years in service. This lack of reliability can be unfailingly detected by the testing system devised by H. J. Force, Chief Chemist and Engineer of Tests for the Lackawanna R.R., in which cement briquettes are for two hours submitted to heat at a pressure of 20 atmospheres.*

A few of the cement companies have been wise enough to adopt the new tests at their own works, but others seem to regard Mr. Force as an enemy of concrete. The fact is, however, that before the development of this new test the Lackawanna engineers had decided to use structural steel in three very long and high bridges; but through Mr. Force's demonstration, it was felt safe to use concrete. One of these structures alone requires over 200,000 bbl. of cement.

Concerning electrolytic injury of structural steel and the brick or concrete piers supporting it, I am permitted to refer trustworthy seekers for facts to a prominent engineer who has had under his charge the restoration of a large number of such cases. This is a matter of the utmost importance since the present regulations of the National Board of Fire Underwriters permit and in some places require the grounding of the "neutral wire" of electric light and power circuits in our modern office buildings, and this at once endangers the steel in contact with the foundations and in some cases jeopardizes the concrete or brick of the foundations themselves. Concrete bridges, viaducts, retaining walls and tunnels may be seriously injured by the return current of electric railways, especially when subjected to leakage from sewers and gas pipes or to surface drainage from streets. In this opinion I am confirmed by the experience of Mr. Cyril de Wyrall, of New York City, who has had many such cases to contend with and restore.

I do not believe in the policy of silence in matters of such vital importance. The average concrete engineer does not realize the existence of this danger. Until he does so, it is useless to approach him with the devices and precautions necessary to obtain perfect protection.

THE PACKING HOUSE TROUBLE

Some of the many problems encountered in the Allentown packing house were pronounced beyond solution by experts; as, for instance, the removing of several thousand square feet of cracked concrete, 3 in. thick, on the lower side of beams and girders without injuring the remainder, and replacing it with dense, moisture-proof new concrete which should firmly adhere to the old. To lay out the requisite protective measures and methods required a very large amount of research work in mechanical, electrical and chemical fields, which fully justifies patent protection.

The greater portion of the injury was made evident by deep cracks in the concrete parallel to the reinforcing rods, which in some places were as much as 6 in. from the surface of the concrete. These cracks appeared only in portions

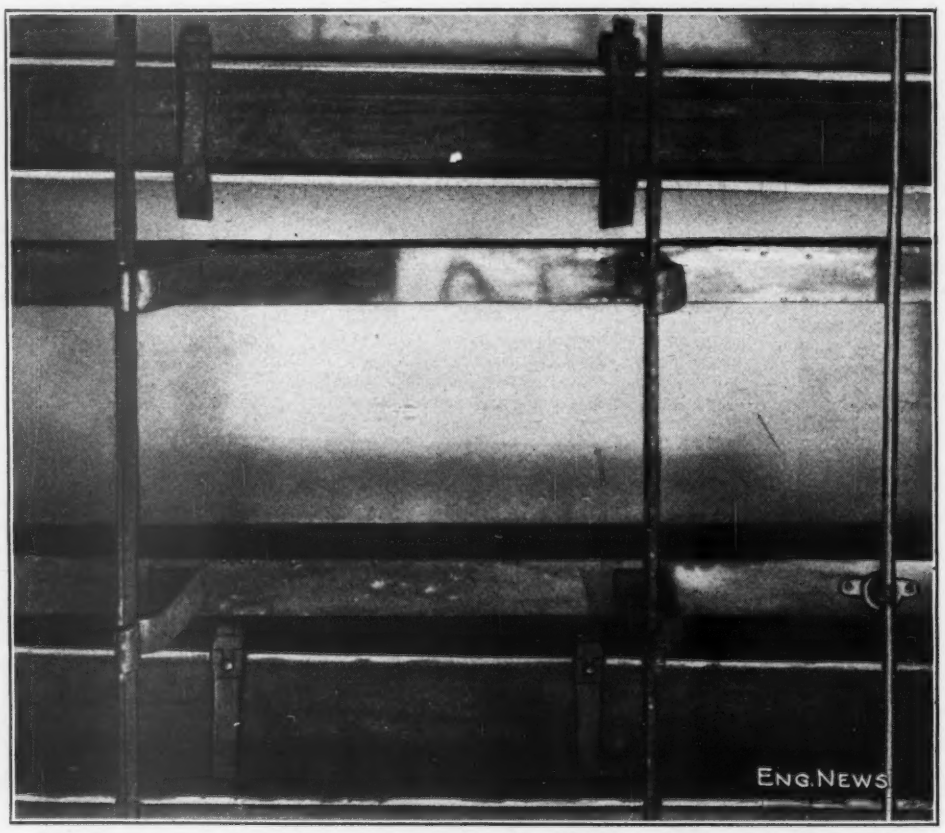


FIG. 3. UNDER SIDE OF REINFORCED-CONCRETE BEAMS AFTER RESTORATION

*Engineering News, June 13, 1912.

of the building where the concrete was wet and where the reinforcement had a positive electrical charge which decomposed the moisture and released nascent oxygen on the surface of the rods. This produced a dense layer of iron oxide which required more room than the iron; the consequent expansion therefore forced the concrete asunder. Wherever the concrete was dry or wherever it was wet without a positive electrical charge there was no damage whatever.

As an electric railway power house was located near this building, it was at first suspected that return current from this source caused the trouble. Had the railway current been responsible, the injury would have appeared in columns or beams in the cellar near the north wall adjoining the power house; the current would then have been traveling north toward the power house. But there was no current in that direction and no sign of injury on the cellar columns, while the soaked with salt water and formed a conductor of very low resistance from attic to sub-cellar. As the building was divided into sections by brick fire-walls, the various grounded circuits gave no indication in the distant engine room through the "ground detector" located there.

No commercial insulated wire could be found which could long resist the combination of heat, cold, steam, vapor, acid fumes and salt water until the General Electric Co. made a special form of its "varnished cambric insulation" to meet the unusual conditions. This insulated wire has passed the severest tests and has given entire satisfaction.

Methods of Electrical Protection

The following methods of protection and restoration were devised by the writer: By means of non-rusting electrical contact alloys applied to the lower surface of the troublesome "sockets," all the reinforcing steel rods in each room

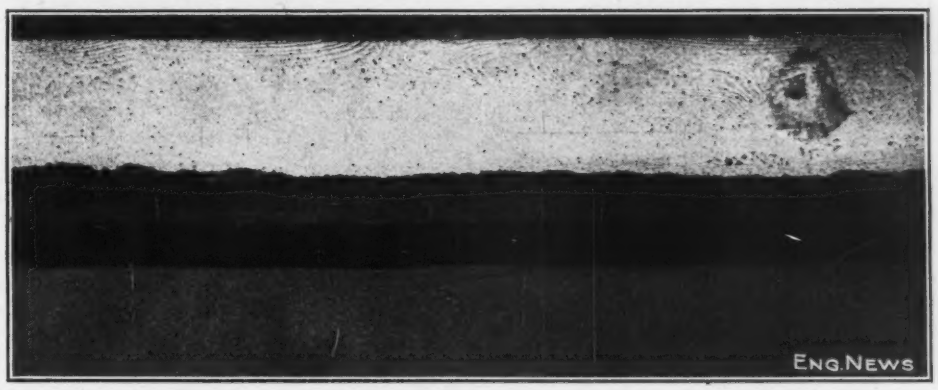


Fig. 4. Side View of Reinforced-Concrete Beam after Restoration
New Concrete, Dark Colored; Old Concrete, Painted White

greatest damage was found in the beams supporting the second floor.

The trouble in this building was caused by electric current leaking from its own power plant, passing through the broken-down insulation on the wires to the metal conduits containing them. These conduits were supported by cast-iron "sockets" which projected from the concrete on the lower surface of the beams and girders, forming a part of a clamping device to keep the reinforcing bars together. Fig. 1 shows the exposed reinforcement of two concrete beams, in each of which three of these "sockets" can be seen. These sockets appeared every 4 to 8 ft.; they were tapped for ¾-in. bolts and were used also to support the water, steam, ammonia and drain pipes and the overhead tramways. Steam, vapor and animal acids condensed in the conduits, since they were open at each outlet. This liquid soaked through the double-braided cotton on the wires and ruined the rubber insulation, immersing the wires in a conducting fluid which through the "sockets" was in metallic contact with the reinforcing rods, thus bringing to them the destroying current. The concrete in many parts of the building was were connected together and a testing wire carried to a circuit-breaker and annunciator in the engine room. All of the conduits were then suspended from mining insulators, cut into sections by insulated joints and connected to similar testing wires, etc.

A low-voltage testing dynamo driven by a motor is operated in the engine room and its current is thrown by a commutating device onto the various testing circuits. Any accidental contact between conduit metal and reinforcement operates a circuit-breaker, releases an annunciator drop and rings a large alarm bell. A similar contact between the power and light circuit and the conduit metal gives the same result. Thus two lines of defence are established, and both must fail before dangerous current can reach the reinforcement. The testing potential connected to the reinforcement is negative and therefore in itself is a protection. To insure the constant operation of the testing dynamo, it is also used to supply current for the elevator bells. The annunciators, circuit-breakers, testing dynamo, etc., are shown in Fig. 2.

At every outlet and at terminals, the electric wiring conduits are filled with a special insulating compound which melts at about 150° F. and is solid at ordinary temperatures; this is done to prevent further condensation of moisture in the pipes since parts of the building are filled with vapor from the cooling carcasses. No provision is made to draw away this vapor and it is allowed to condense and freeze on the ammonia pipes in the coil loft and soon covers the pipes with ice which has to be chopped off and thrown out. This condensed animal vapor is an excellent conductor and is very active in corroding metal, especially when electrically charged.

The switches and distribution boxes are insulated from the walls; the motors are placed on insulated supports and all metal pipes are as far as possible insulated from the reinforcing rods. These measures were adopted several months ago and have proved effective protection.

Replacing the Damaged Concrete

The cracked concrete was removed by the use of a light pneumatic hammer whose blows could not injure the solid concrete above the rods. The thick layer of iron oxide was taken off the lower surface of the exposed rods by the sand blast. Then boards extending down to the level of the former surface were clamped on the sides of the beams and girders, as is shown in Fig. 1, which was taken with the camera pointing upward. To fill this space with a 3-in. layer of dense, moisture-proof concrete, which would firmly adhere to the old work, involved many serious problems. It was at first thought that the "cement gun" would meet the requirements; but for several reasons it had to be given up. In using this apparatus a large amount of the finely powdered cement floats away; this settling on fresh meat makes an unpleasant combination as it will not easily wash off. Then "gun" concrete cannot be made moisture-proof nor can a 3-in. layer of it be made to adhere to an overhead ceiling surface.

I was fortunate enough to obtain the use of the first "Pactor" machine, a recently invented apparatus which is like the "cement gun" in using the force of compressed air to discharge a stream of concrete from the nozzle of a hose, but which delivers wet concrete, and thus does not scatter sand and cement dust like the earlier machine. Unlike the "gun," the concrete for the "Pactor" can be properly proportioned and carefully mixed and the hopper kept filled without stopping the work. The product is therefore absolutely uniform. This machine required about 125 cu.ft. of free air per minute at 30 lb. pressure, which was furnished by one of the compressors of the ice machine in the engine room. As most of this work was done in refrigerated rooms with low temperature, it was necessary to heat the air to prevent freezing. This was done by placing

a 70-ft. coil of 1½-in. pipe in a barrel filled with steam at low pressure.

It was important that the new concrete should be moisture-proof; therefore the water used was mixed with the proper amount of waterproofing compound with a mortar of 1 part of portland cement to 3 parts of sand. At first the stuff would not stick overhead, though it settled firmly on the columns. It would spatter off, blow off or peel off the lower surface of the beam in a most disconcerting manner, until the proper adjustment was found of consistency of mortar, speed of engine and air pressure. Then the concrete packed itself firmly into place as shown in Fig. 3. A float was used to level the surface and the following morning the new concrete was found to be solidly attached to the old. Fig. 4 shows a side view of one of the restored beams whose new concrete was so hard after seven days that a hammer and chisel vigorously handled could not detatch it from the old. In 28 days it was far stronger than the old and was absolutely damp proof.

Fig. 5 shows the standard form of the Pactor, and Fig. 6 an operator at work.

Waterproofing the New Concrete

In new structures, the first step in safeguarding concrete against electrolytic injury lies in the adoption of such of the electrical devices above described, as are required by the conditions. The next step, which is fully as important, is to make the concrete itself proof against both moisture and current. As above stated, it is not enough to make it sufficiently heavy to check the flow of water; it must be made absolutely moisture proof. This can be done at a moderate cost and is well worth while for other reasons than protection against electrolysis, for Prof. Alfred H. White, of Michigan University, has shown that ordinary concrete which is free to absorb water will increase in bulk when wet and shrink when dry. This variation will sooner or later cause cracking and, of course, subsequent freezing when soaked with water will produce trouble.

In an article upon tests of waterproofing materials by Messrs. R. J. Wig and P. H. Bates, issued by the U. S. Bureau of Standards, the authors say:*

> Portland-cement mortar and concrete can be made practically water-tight or impermeable (as defined below) to any hydrostatic head up to 40 ft. without the use of any of the so called "integral" waterproofing materials. The terms "permeability," "absorption" and "damp proof" should not be confused. A mortar or concrete is impermeable (not necessarily damp proof) as defined and used throughout this report, when it does not permit the passage or flow of water through its pores or voids. The absorption of a mortar or concrete is the property of drawing in or engrossing water into its pores or voids by capillary action or otherwise. If the pores or voids between the grains or particles or in the individual grains are sufficiently large and connected from surface to surface of the wall, the concrete will be permeable to water. If the pores or voids are very minute, but connect one with another, theoretically they may act as capillary tubes, absorbing or drawing in and filling themselves with water; but the capillary forces will tend to hold the water in the pores and will prevent the passage or flow of water, even though one surface of the wall may be exposed to a considerable hydrostatic pressure. For all practical purposes a wall under such conditions would be considered perfectly water-tight and impermeable, although it may be highly absorptive.
>
> If these minute pores do act as capillary tubes and are never minute enough to prevent capillary action, the moisture either as water or water vapor would in time penetrate entirely through and fill a concrete wall, no matter what the thickness or composition. In such a case the capillary forces would not permit an actual flow of water, but these forces may carry moisture, entirely filling the wall, and unless evaporation is retarded, the opposite face of the wall would appear dry. In such a case the concrete would be considered impermeable, but not damp proof.
>
> The damp-proofing tests as conducted would indicate that portland-cement mortars can be made not only impermeable, but damp proof as well, as defined above, without the use of any damp-proofing or waterproofing compound. (Since the completion of the investigation reported above subsequent tests of similar materials have further shown the ineffectiveness of such materials). However, these tests should be interpreted with caution as the evaporation may have been sufficient to care for the slight amount of moisture coming through the test pieces without indicating on the filter paper.

*Engineering News, May 2, 1912.

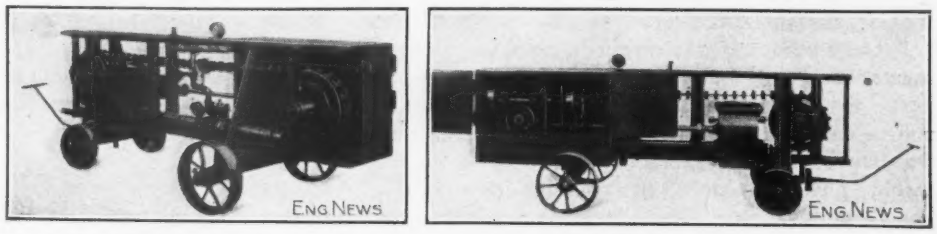


Fig. 5. Views of Portable "Pactor" Machine for Delivering Mixed Concrete through a Hose by Compressed Air

Fig. 6. Concrete Column Injured by Electrolysis and Operator Applying Concrete to Beam with Hose from Pactor Machine

The method of testing for damp-proofing used by these authors was to place blocks of concrete 2 in. thick in a trough containing water ½ in. deep and to paste on the tops of the blocks filter paper painted with phenol-phthalein which turns pink in presence of alkaline water. The water had to climb upward 1½ in. by capillary action before it could penetrate the paste, soak into the paper and indicate its presence by discoloring the chemical.

This test is not severe enough to meet electrolysis prevention requirements, for should the water penetrate the block merely up to the water level, the current would follow and perform its destructive work, even though the filter paper were not reached. To obtain protection, moisture must be absolutely excluded.

My scheme for testing the damp-proof qualities of concrete consists in the use of blocks of concrete 5x4⅛x9⅛ in., containing two steel rods 1 in. diameter placed ¾ in. apart entering the top and penetrating 5 in. The blocks are placed in a 10% solution of salt water 8 in. deep and the steel rods connected to the terminals of a dynamo with a potential of 125 volts d.c. With plain concrete of best quality, carefully tamped, and placed in a moist room for 28 days, then allowed to dry thoroughly under ordinary conditions, the closing of the circuit after immersion soon showed the penetration of the water by an increase of temperature with heavy flow of current. In two days a coating of iron oxide had formed around the positive rod and was dense enough to crack the concrete. Seven days later this crack had widened to $\frac{1}{16}$ in. from end to end of the block through about 2 in. of solid concrete. There was no crack around the negative rod. With alternating current both rods are corroded at about half this rate.

I have carefully tried various oils, asphalts, stearates, resinates, etc., for waterproofing concrete, but do not find any of them to stand up under the severe tests which I have described. The first two injure the tensile strength and will sooner or later hydrolize and wash out when submitted to water and the weather.

None of them will withstand the combined action of heat and water. Soap compounds such as stearates and resinates may at first make the concrete repel water, but they soon lose their efficiency, especially when exposed to leakage from sewers and gas pipes.

Only one compound was found which stood up under these severe conditions and showed itself able to absolutely exclude moisture and current flow. This is an inexpensive paste called "Starex" which is mixed with the water used in the concrete.

A test block was made in September,

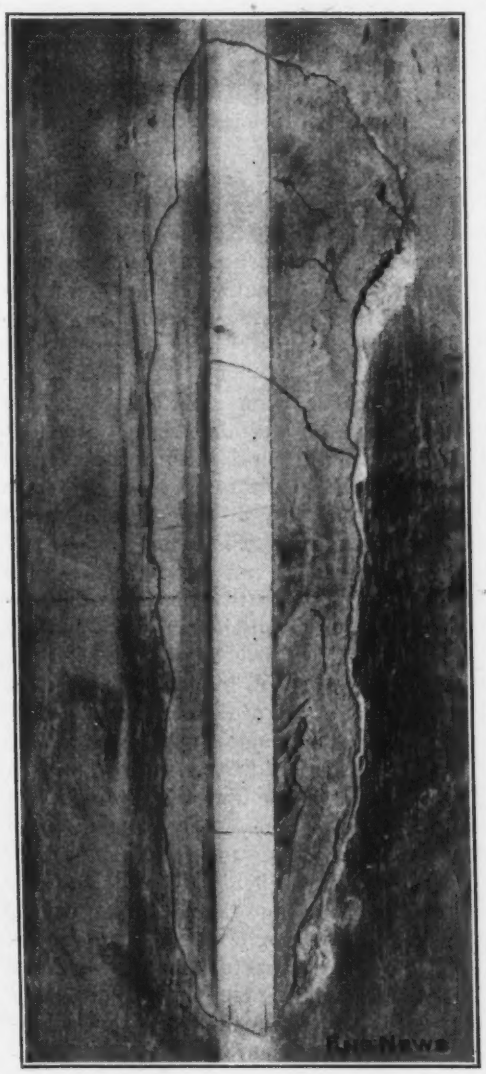


FIG. 7. SHRINKAGE CRACKS CAUSED BY ACCIDENTAL OMISSION OF "STAREX" FROM CONCRETE USED IN RESTORING INJURED COLUMN

1911, containing 5 parts by weight of portland cement, 15 parts of sand, 2 parts of "Starex" and 2½ parts of water. As the repairs had to be made in several refrigerating rooms at low temperature, this block was placed in an ammonia coil room at 28° F. for 14 days and then cut into sections for examination. When removed it was found to be covered with a layer of ice ½ in. thick. It was close in texture, weighed 120 lb. to the cubic foot and took a high polish. A similar block after 30 days' hardening was put into salt water and its rods connected with the mains of a direct-current dynamo at 125 volts. Since Nov. 8, 1911, it has been under this pressure continuously and shows no sign of current flow nor injury. Without "Starex," similar blocks rise in temperature at once and crack around the positive rod in two days.

In applying 3000 lin.ft. of "Starex" concrete at the packing house above referred to not a single shrinkage crack was found. Through a misunderstanding, on the last day's work no "Starex" was used in mixing the concrete, and cracks appeared on every portion of the finished surface. This is shown in Fig. 7, where a new corner was placed on a cracked column.

Remarkable density is obtained when this compound is used in concrete placed with the "Pactor" machine. A cubic foot of this concrete, mixed rather dry as is necessary where it has to be applied as a plaster, will weigh 120 lb. when hand tamped; it will weigh about 150 lb. when applied with the "Pactor."

"Starex" appears to consist of a bituminous waxlike substance, reduced to impalpable fineness and made into a paste with powdered inorganic materials. It readily forms an emulsion in water and remains in suspension with but little stirring. If the hand is dipped into the dilute emulsion, a waxy film is left on the skin which is hard to remove after drying. A similar film is left on sand or stone dipped into it. By mixing with the water to be used for the concrete an amount of "Starex" equal to 10% of the weight of the cement and sand used in a 1 to 3 mortar, not only is the ease of working enhanced, but the concrete in setting apparently does not alter its mass. Before setting, the mortar is very plastic and can be given a high polish with a float. At the end of 14 days a tensile strength of over 500 lb. to the square inch is shown. As the concrete sets, certain constituents of "Starex" seem to unite with the siliceous materials, forming a compound of greater density which fills the space vacated by the water, leaving practically no voids.

Regulation of Engineering Practice in Austria—A new departure is being undertaken in Austria to improve the status of engineers in the community. A bill has been placed before the legislature, which will call for the establishment of bodies similar to chambers of commerce or bar associations, but of official character to the extent that membership is required of those practicing engineering. A hearing on the bill was held by a committee of the Abgeordnetenhaus, on June 10 (see "Zeitschrift des oesterreichischen Ingenieur und Architekten Vereines, June 21, 1912), at which a number of speakers for the engineering profession spoke in favor of the bill. The Minister of Public Works also advocated the bill. The committee thereupon approved the bill and decided to report it to the legislature.

The Engineer in the Public Service*

BY F. H. NEWELL†

The needs and opportunities in modern life for the engineer are steadily increasing. Each new invention creates new demands. The number of persons now engaged in engineering pursuits is not accurately known, but is far greater in proportion than in former decades. In the public service, however, it is not up to the real needs.

Throughout the entire political organization, there has been and still is a tendency to ignore the special training of the engineer in civic affairs. This is due largely to the engineers themselves and to their organizations, some of which, in their ultra-conservative attitude, tend rather to repress than to push forward the claims of the engineer for recognition as a factor for good in the larger affairs of the country.

Judging, however, from the developments abroad, with increase of knowledge Americans will begin to understand that the conduct of many of our larger public affairs can be entrusted with safety only to the men who have been trained in such business and who may look forward to continuity of employment such as will enable them to perfect themselves in the details of public service.

In public service, more than in any other class of engineering work, a knowledge of men, especially in groups, is more important for success than almost any other single item. The training of an engineer begins mainly with the facts as to the strength of materials and the action and reaction of the forces of nature. At the outset he must understand thoroughly the machinery with which he is to achieve results. But the most important, after all, of the machinery with which the engineer has to do is the human machine, including in this the laborers, the foremen, the engineering organization, and all others, together with their peculiarities of mental and physical make-up.

Some good engineers never learn and never can successfully operate the human machine. By temperament and choice they prefer the quiet of the office; removed from contact with their fellow men they do excellent work; but this is rarely possible in a larger way and particularly in public service where effectiveness is dependent very largely upon the tact and discretion which comes only from an intimate knowledge of bodies of men and their motives.

It is of advantage to the beginner in engineering work to work at first under experienced men and by contact with

*Condensed from an address before the graduating class of Case School, Cleveland, Ohio, May 29, 1912.

†Director, U. S. Reclamation Service, Washington, D. C.

them to gain a broad viewpoint. You will be thus afforded an opportunity for the development of sound judgment which can come only from contact with men and affairs.

Even though placed in relatively humble positions at first and with little apparent influence on events in general, it is possible for you to have more or less to do with directing details. If this discretion is wisely exercised, you may gradually acquire a hold upon larger affairs.

Efficiency is the watchword of the engineer. The time has gone by when men took pride in a great engineering structure or machine simply because of its elaboration and intricacy. They now ask not merely what it does, but how efficient is it? That is to say, what is the relation between the work or energy put into the machine and that which comes out of it in useful results?

We must know not simply how much money has been spent or what a given machine or operation has cost. This is only one side of the story. The other, more important and more difficult sometimes to ascertain, is what has been procured by this expenditure. If we are buying lumber or steel, we can very quickly give the results in terms of materials purchased, but this does not tell the story of the engineer's efficiency. When the materials assembled by labor and by complicated operations are wrought into structures properly planned and supervised and a large organization economically maintained, then the really difficult and important matter of cost shows the efficiency of the engineer.

What does it cost per square yard to pave a street? What does it cost to lay a mile of railroad? What does it cost per yard to build earthworks? These questions sound very simple but when you begin to prepare your estimates, you are confronted with innumerable questions as to what is to be included. If you are told to include everything, then comes the more difficult problem as to what not to include.

The result of studies of cost, whether made by you individually at odd moments or officially for your employer, or for the public, should always be given not merely in actual expenditures but in terms of the results attained. A good system of cost keeping in which all of these items are included is invaluable, while a defective cost system which does not take into account these ramifications may be worse than useless, as it is misleading.

The principal items of real cost are frequently those which are commonly neglected. The reason for the failure of many enterprises has been not that the engineers have underestimated the cost of the structures themselves, but that they have not considered it their duty or have not had sufficient experience to be able to include proper allowance for the cost of administration and the items, such as depreciation, insurance, promotion, etc., which should fall within the knowledge of the business man.

You will find that in the long run, especially in public affairs, your reputation is dependent largely on the maintaining of records of this kind which will give all of the facts of cost and of related incidents such as to protect you from the effect of sudden attack.

As a very trivial matter, for instance, may be cited the keeping of a personal diary. Some men do this as a matter of habit, while others seem to regard it as too trivial. In engineering construction, especially on public works, it has been found advisable to insist that each of the principal men keep a somewhat personal diary, showing where they were and what they were doing at different times of each day, later turning this in to become part of the official records.

You, as inspector or resident engineer or later as the principal engineer on the work may have the most amicable relations with your contractors, or with the world in general, but sooner or later you will be confronted with questions or claims whose settlements may be facilitated by the reference to these apparently insignificant memoranda. It is astonishing how claims arise, especially in public work, and how they assume enormous proportions unless confronted with facts and dates.

It may sound odd to urge as a guiding principle of success that the man in public work, especially in engineering, should continually seek publicity and yet this is a condition which is frequently overlooked. Publicity, not of the personality of the man in charge, but of the work itself is vital to its continuation. Strangely enough, many of our best engineers and scientific men in the employ of the public seem to shrink from taking the public into their confidence and from giving out from day to day the essentials of methods and costs. They seem to be guided by the old rule that "fools and children should not see things half done" and to regard the public as a combination of both!

It is true that the law usually requires an annual report, but this is more or less perfunctory and usually contains a statement of what the work should be, rather than what it actually is. As a result, operations which are useful and necessary in themselves may go on year after year, and then suddenly the public, or more likely a small minority of the public having some personal end in view, will precipitate a sudden attack at about the time the operations are reaching completion, tending to cripple or destroy them.

It is one of the problems of the engineer in public service how to guard his structures from such sudden gusts or upheavals. He studies, it is true, the stability of his works on the ground and their ability to resist shock or wind pressure, but too often he neglects to take the same precaution against the fickle waves of public opinion and does not foresee and study the commotions which are likely to disturb his organizations.

The great safeguard against unstable conditions of this kind is a thoroughly educated public opinion, one which cannot be created in a day or a week, but which is the result of continual sustained educational effort day by day throughout the duration of the work. This can be achieved only by the daily giving out through every available channel of those facts or figures showing achievement or costs and results such that they can be understood by the public and become a part of its general knowledge.

"In time of peace, prepare for war." This motto may be paraphrased by the engineer in public service and he should keep always before him "in time of tranquility prepare for investigations." One of the characteristics of public-service work is the alternation of quiet progressive work followed by storms and interruptions which—if not foreseen and guarded against—may be destructive. With a reasonable amount of foresight, it is possible to outride these storms, in fact, it is hardly creditable to the capable man not to be able to do so, as they are part of the natural phenomena accompanying affairs of this kind.

The reason is not far to seek. The public as a whole is a lenient or somewhat indifferent employer. It pays little attention to its own affairs, but having turned them over to its servants, assumes that these will proceed in a satisfactory manner. Any employer who does this, who is not eternally vigilant and who is not thoroughly familiar with technical or professional details is invariably disappointed with the results. He expects the impossible and when he learns that the impossible has not been accomplished, he is correspondingly vexed. In the public, this vexation takes the form of vague criticism or dissatisfaction, and generally crystallizes into demand for investigation or reform or for change of some kind or another.

As before stated, these are conditions which must be well understood in advance, and to meet which reasonable precautions must be taken exactly as they are allowed for in our calculations of extraordinary floods on our dams or violent wind pressures on bridges and roofs. There is no occasion for alarm or disquietude when these do occur if reasonable precautions have been taken. These consist, as before stated, of having had in advance as full publicity as possible of the details and also having in reserve a complete and exhaustive statement of methods, costs and results, with detailed records which show the steps taken in arriving at any course of procedure.

Assuming that throughout all of these

developments, there has been integrity and reasonably good judgment displayed, with necessary regard for legal requirements coupled with a full consideration of the interests of the public, there is little to be dreaded, excepting the loss of time and of energy incidental to the storm.

A well equipped man, while regretting the delays and wasted energy, to a certain extent may welcome an event of this kind, as affording him an opportunity to show what has really been accomplished. He may be enabled to direct public attention to the larger features of his work and to important details which would not otherwise be appreciated. If he has real genius he may be able to turn the attack to the advantage of the work itself. This attitude of mind has been described in a popular phrase which describes the truly efficient man and optimist as being one who can "make lemonade in the evening out of the lemons that have been handed him during the day."

This situation was humorously referred to by our ex-president Theodore Roosevelt about a year ago at the dedication of the Roosevelt dam in Arizona, the largest and most important structure of this kind built by the Reclamation Service. After speaking to the citizens of the excellent results which might be expected from the use of this great structure in the conservation of the water supply and dwelling upon its importance not simply to the neighborhood but to the country at large, he touched upon the high degree of efficiency and economy reached by the engineers in the completion of this work, commended them highly for it, and then added, with a smile, "Of course, your reward will be a Congressional investigation." His prophesy was fulfilled. In less than twelve months, the men who had devoted the best part of their lives and energies to this work were being investigated.

Efficiency should apply to the individual as well as to the organization. Constant attention and study must be made and critical consideration given to the relative importance of all of the details of official life. Nearly every engineer in an important position has on hand two or three times as much work as can be given proper attention and usually those items are most attractive to him which really have the least importance. It is a process of continual self-denial to shove aside the minor matters which are attractive, in order to push forward those which are distasteful but upon which hinges the successful outcome of the work.

It is well to consider each demand upon the working time and energy as falling under one or another of two headings: *first*, constructive, that is to say, leading to accomplishment, and *second*, obstructive, or destructive, tending simply to hold back performance.

When this is done you will be surprised to find how much of your time, unless you guard against it, is being devoted to purely obstructive detail, to matters which do not properly pertain to your work. In the case of any man prominent in official affairs, a great part of his time is unfortunately devoted to applicants for employment. Even under a highly developed Civil Service, it is impossible, using proper courtesy, to refuse to listen to many hard-luck stories. It requires experience and skill to do this quickly and effectively, and with the consideration which is due to the unfortunate and deserving.

A large part of your time will also be wasted, unless you guard against it, in matters which after careful analysis you see are not those for which you are employed, but which are an unnecessary outgrowth or branching away from the main line. It is so easy to diffuse, to branch out. Concentration is difficult and requires persistent determination.

Whatever may be the political or other conditions, the powers that be are always looking for a man who can accomplish things, either himself or through others. He may not apparently obtain the credit for it, but few employers, whether the public or a corporation, fail to discover finally the man who is accomplishing results. Whether the direct credit is given to him or not, counts for very little because there is in these matters frequently a curious inversion or reversal of credits. The things which you do and upon which you pride yourself are rarely those for which you obtain general recognition, whereas, if you obtain any reputation at all, you will be surprised to find that it is usually based upon what you regard as trivial or non-essential.

Shipping Cement in Bulk has been initiated by the Universal Portland Cement Co. The company has issued the following statement:

Recently a carload of Universal left the mill at Buffington, consigned to Milwaukee. The experiment proved highly successful in every way.

The car arrived at its destination with absolutely no signs of loss or damage. The cement was left smooth and undisturbed in apparently the same condition as when it left the mill. The car was unloaded with shovels into wheelbarrows and the operation seemed to cause less dust than does the handling of cement in sacks. Some of it was wheeled directly to the mixing plant of a block and sewer pipe factory and the rest of the cement was stored in a warehouse.

Dealers and cement users who have to team will probably continue to demand shipments in sacks, but factories making cement products and contractors doing big jobs adjacent to railroad tracks and using central mixing plants could probably be served better and more economically with bulk shipments of cement. The experiments may show that a large amount of capital is unnecessarily tied up in sacks and if it is found that cement can make a trip from the mill to the job in bulk just as well as in sacks, a heavy item of expense will be eliminated.

Grain and other commodities having a much higher value per ton are shipped in box cars in bulk. It is believed that with a very small investment in unloading equipment and storage facilities, those who receive shipments of cement will find it a paying proposition to receive carloads in bulk.

Arch Dam Design: The Constant-Angle Arch Dam

By Lars Jorgensen*

Many of the best dams have been built with a gravity section but curved in plan, the curve inclosing a smaller or larger angle as the case may be. The curved form is supposed to give additional strength to the structure, and it undoubtedly does so at and near the crest, especially if the arch incloses a large angle.

In a curved dam, both load and decrease of temperature tend to shorten the arch, and the only way the structure can compensate for this shortening is by deflecting downstream. If the cañon has a fairly regular shape, the deflection will be greatest at the crown of the arch and will decrease somewhat uniformly to zero at or near the abutments. Bearing in mind that the most common shape of a dam-site is of V-form, it is easily seen that, even if the arch incloses a large angle at the top, the angle is bound to become small at lower elevations, i.e., the arch becomes flat. Therefore the ability of such a structure to take up arch stresses decreases toward lower elevations, and at the foundation the value of the arch is not great. This means that at the bottom the dam has to act as a cantilever, and, therefore, the section must be a gravity or near-gravity section, in order to be conservative.

This condition, however, exists at the crown only. As the abutments are approached the deflection becomes less and the arch action more complete, until at or near the abutments, where arch action can take place most completely.

From the very nature of the stresses it is evident that, where the site will allow an arch dam at all, a dam will be the safest and most economical when it is designed to take most of the load by arch action. The distribution of stresses due to the arch action is perhaps not exactly uniform, but the difference between unit-stresses at the two faces is in most cases not great. On the other hand the stresses due to gravity action are very poorly distributed, and therefore the material is not utilized in an economical way. With reservoir full, the extreme fibers at the toe and along the downstream face are subjected to the highest compression, while the remaining material is subjected to a very much lower compression, reaching zero or nearly zero at the upstream face. Also, with absolute arch action no shear is present, whereas in the case of cantilever action the shearing force is equal to the whole force causing the bending.

In designing an arch dam it is convenient to start with the usual assumption that any horizontal element is a por-

*Engineer with F. G. Baum & Co., Inc., Chronicle Bldg., San Francisco, Calif.

tion of a cylinder ring (Fig. 1) in which the average stress q (lb. per sq.ft.) is equal to the radial load P (lb. per sq.ft.) multiplied by the radius of the exterior face and divided by the thickness of the section:

$$q = \frac{P\,(R+t)}{t} \qquad (1)$$

in which t equals the thickness of the dam at any given point, and R is the radius of the downstream face.

The volume of concrete in any arch dam is equal to the area of the dam section, times the mean radius, times the inclosed angle in terms of π, or

$$V = A \times R_m \times 2\theta \qquad (2)$$

V being the volume, R_m the mean radius, and 2θ the inclosed angle in terms of π. The mean radius R_m equals the radius of the downstream face plus half the thickness t, and also equals half the width w of the span divided by the sine of half the subtended angle

$$R_m = \frac{\frac{1}{2}w}{\sin\theta} \qquad (3)$$

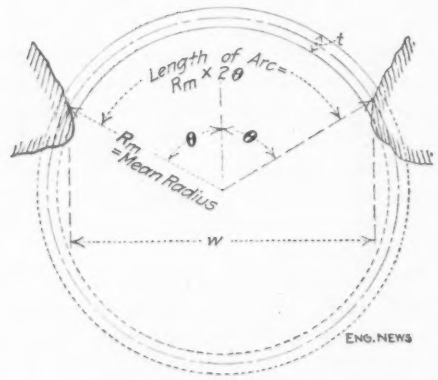


FIG. 1. HORIZONTAL SLICE OF ARCH DAM, SKOWN AS PART OF A RING UNDER EXTERNAL PRESSURE

Now, as the area of the arch dam section varies with the radius, the volume of masonry is

$$V = \frac{C \times (\frac{1}{2}w)^2 \times 2\theta}{\sin^2\theta} = \frac{K \times \theta}{\sin^2\theta} \qquad (4)$$

in which C and K are constants, the latter depending upon the width of the cañon.

From Eq. (4) it is seen that the volume varies with $\frac{\theta}{\sin^2\theta}$. The differential coefficient of this term equated to zero gives the minimum for a central angle of 133° 34′, which means that the dam, or any horizontal slice of the dam, has least volume when $2\theta = 133°\ 34'$. This is shown graphically by the curve in Fig. 2, in which the abscissas represent the central angle 2θ and the ordinates are $\frac{\theta}{\sin^2\theta}$, the latter being proportional to the volume of masonry. From this curve it will be seen that the amount of masonry required for any curved or arched dam, where arch action alone is depended upon for strength, will be a minimum when the mean radius at any elevation is so chosen that the inclosed angle 2θ is about 133°. The curve also shows that so long as 2θ is held between the limits of 120° and 146° the variation in the amount of masonry is only about 1%. This fact is the basis for the new design of arch dam described below.

The main feature of this new type, and the one which makes high economy of construction feasible, is keeping the subtended angle of the arch as nearly constant as possible, and as near to the most economical value at any elevation as the contour of the dam-site will permit.*

This necessitates the abandonment of the constant upstream radius generally employed in arch dams as at present constructed, and the substitution of radii of varying length determined by the width of the cañon at any elevation.

The method of design involves the independent determination of the dimensions of successive arch-shaped slices of the dam lying between predetermined levels, each slice being considered as an independent structure for the purpose of facilitating calculation, such slices being thereafter superposed to form the dam body. Referring to Fig. 3, the procedure for determining the contour of the faces of the dam therein shown is as follows:

Six elevations have in the present instance been established, forming the contour lines I, II, III, IV, V, VI, the contour line VI corresponding to the level of the water retained by the dam, while the contour iine I corresponds to the lowest dam level. The distance across the cañon at the top (contour VI) of the dam, w_6, is ascertained (measured on a map to scale). Then the mean radius $R_6 + \frac{1}{2}t_6$ which will give the dam the greatest strength with the least volume of material is found by selecting the economical central angle 2θ; the economical mean radius will be $\frac{\frac{1}{2}w_6}{\sin\theta}$. At the top of the dam it will generally be found of advantage to choose 2θ near the upper limit (146°), as at the bottom the site generally compels the use of angles smaller than would give the highest economy. After the most economical mean radius for this elevation has been ascertained, the thickness t_6 may be algebraically determined from the foregoing equations.

The first relatively abrupt change of slope of the cañon sides occurs at elevation V. The distance across the cañon at this elevation being measured, w_5, the most economical mean radius of the section is found, as before; the thickness t_5 is computed, and the upstream and downstream radii are determined. The center of curvature of the arch slice at elevation V, with thickness t_5, does not necessarily lie on the same center line as the center of curvature of the arch slice at elevation VI; in fact, it practically never will do so, as perfectly symmetrical slopes of the cañon sides will rarely be found.

Elevation IV is coincident with another change of slope in the sides of the cañon. The most economical mean radius corresponding to the fixed distance w_4 across the cañon at this elevation is found, and the location of the center of curvature of the arch slice at this elevation is fixed regardless of the location of the centers of the slices at elevation VI and V. Thus, the dam has no common center line, and centers are located principally with a view to getting the length of the arch as short as possible for a given distance across the cañon, and also with a view to getting a practical structure easy to construct and with smooth faces.

The radii and thicknesses at elevations III, II and I are correspondingly determined in accordance with the procedure above outlined.

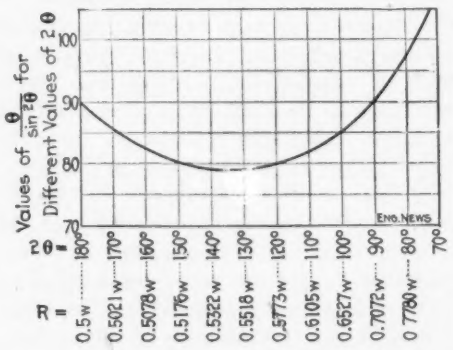


FIG. 2. CURVE OF VOLUME COEFFICIENT FOR ARCH DAM, FOR VARYING CENTRAL ANGLE

(The lower line of figures gives the radius in terms of span of arch.)

So far only the average stress q has been considered in determining the thickness of each arch ring. Toward lower elevations, where the thickness t of the different arch slices is considerable, it is necessary to investigate also the maximum stress to be sure that this is not above the safe limit. The maximum arch compression will be approximately equal to

$$\frac{2\,(R+t)}{2R + \frac{3}{2}t}$$

and will exist along the downstream edge.

After having calculated the different radii and respective thicknesses of the several horizontal slices of the dam, the top thickness (which is generally chosen arbitrarily) is set off, and the arcs of two concentric circles, with radii R_6 and $(R_6 + t_6)$, respectively, are drawn in on the map; their centers will, of course, be on a normal to the center of the chord w_6. The thickness t_5 is then set off, and the arcs of the two other concentric circles, with radii R_5 and $(R_5 + t_5)$, re-

*On this feature a patent has been granted to the writer, and this type of dam is now being exploited by the firm of F. G. Baum & Co., Engineers and Constructors, San Francisco, Calif.

spectively, are drawn in, bearing in mind that the center line of these arcs does not need to be on the perpendicular to the chord w_6. These four circles, concentric only in pairs, determine the contour of the dam between elevations VI and V. It is usually convenient and preferable to assume the downstream faces of the dam slices to be vertical near the center, at least for the first trial; later, material may be added at the toe to take care of the stresses due to cantilever action, and in case the dam is very high this will be necessary.

A certain amount of discretion must be exercised in locating the centers of the respective arch slices, especially where a very abrupt change occurs only at one side of the cañon wall. In some localities it may be desirable to face the dam with stone, and it may then be of advantage to step the faces of the dam off. The dam will then consist of a number of cylindrical rings superposed one upon the other. The upstream and downstream radii in such case are ascertained in exactly the same manner as in the foregoing.

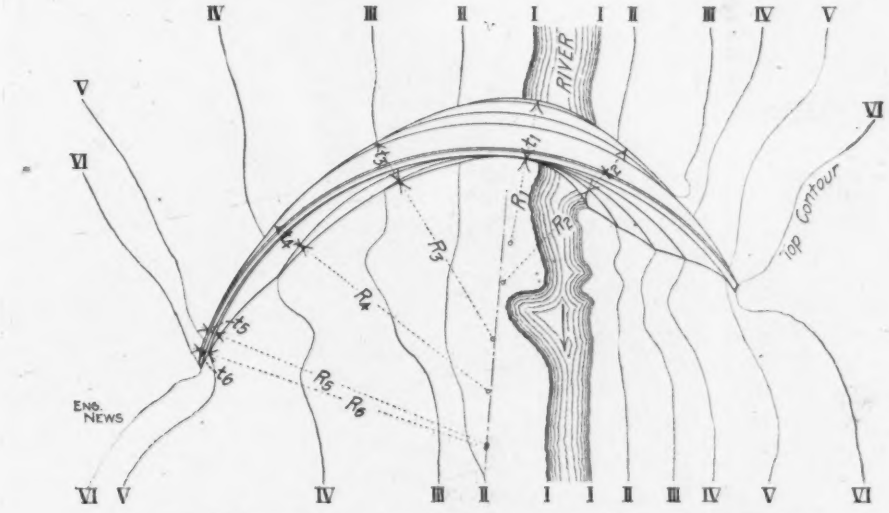


FIG. 3. CONTOUR PLAN OF VALLEY, AND LAYOUT OF ARCH DAM

If it is desired to prevent overhang, it will be necessary to have the thickness t increase from crest to foundation. The proportional increase in water pressure must, therefore, be greater than the proportional decrease in length of the upstream radius toward the foundation. The ratio of increase in water pressure is always fixed, and the ratio of decrease in the length of the upstream radius depends upon the slope of the cañon sides. If these slopes are such that at any intermediate elevation the ratio of decrease in length of the upstream radius (corresponding to a 133° central angle) has been greater than the ratio of increase in water pressure, a decrease in the thickness of the dam at this elevation would result and the structure would be overhanging. Whenever a certain thickness must be provided to prevent overhanging, it is most economical, if no other considerations have to be made, to increase the length of the upstream radius above that corresponding to a 133° arch for the reason that a flat arch requires less material than a more curved one of the same thickness.

In the foregoing the thickness t of the different arch slices has been determined as if all the load were taken by the arch and the gravity of the mass not utilized at all. This should give a safe dam, and many engineers consider such method of calculating arch dams sufficient and on the safe side, as absolutely accurate methods for finding what proportion of the load is taken by the arch and what proportion is taken by the cantilever do not exist. Approximate methods for finding this division of load have been thoroughly discussed in a paper entitled "Lake Cheesman Dam and Reservoir," by C. L. Harrison and S. H. Woodard, and in the discussion following that paper (*Trans.* Am. Soc. C. E., Vol. LIII, 1904, p. 89).

R. Shirreff in his discussion of that paper develops the following formula for the crown deflection of any such dam:

$$\frac{C \times P\,(\textit{upstream radius})^3}{E \times t}$$

where C, a factor which takes the curved-beam action into consideration, can be directly found from Fig. 22 in Mr. Shirreff's discussion. The formula shows that the deflection of the arch dam when loaded is practically proportional to the square of the upstream radius divided by the thickness t. In the new type of arch dam the length of the upstream radius near the foundation may be only one-fourth of the crest radius. The thickness t may be only one-half or one-third the thickness required for the old type. The resulting deflection of the crown near the foundation will, if free to move, be one-eighth to one-fifth of what it would have been if a constant upstream radius had been used. In other words, this new type of dam is able to take up five to eight times as much of the load near the foundation acting as an arch for the same deflection as the old type built on the same site. This means that there will actually be five to eight times less for the cantilever to support; it is, therefore, evident that cantilever action cannot predominate in this type of dam, and shearing stresses must be unimportant.

The small average deflection characteristic of this type of dam will make it possible for the structure to take care of stresses due to temperature changes, eliminating cracks either entirely or to a large extent. As the ends of the arch are fixed to the abutments, the shortening or lengthening due to temperature changes either causes cracks to develop or forces the crown back or forth. In this new type, the average deflection being much smaller for the same amount of decrease or increase in length of arch than in the old type, the stress necessary to cause this deflection may not exceed the ultimate strength of the concrete, in which case no cracks would develop. In any event cracks are not as liable to occur as in the old type, and the objection generally made against arch dams, that they cannot deflect sufficiently toward the bottom to take much load, has but little weight in the case of the new type, where the deflection required to support a given load is very much smaller than in the old type, due to the shorter radius.

A Trainshed Roof of peculiar design has been adopted for the new passenger station of the Havana Terminal Ry., at Havana, Cuba. The roof is 67 ft. wide, with a central steel truss span of 43 ft. (about 5 ft. deep), and two 12-ft. cantilever spans inclined upward from the columns which carry the trusses. The columns are in the middle of 20-ft. island platforms. The central span covers two tracks, and over each of these is a longitudinal opening in the concrete roof slab, with concrete longitudinal walls extending above the roof and below the lower chords of the trusses. This arrangement is similar to that of the Bush type of trainshed, but has the special feature that each of these longitudinal openings is covered by a concrete roof projecting beyond its walls, these walls having openings above the level of the trainshed roof for the escape of smoke and steam discharged by the engines. In this way the interior of the trainshed is protected against the entrance of rain, while with the ordinary arrangement a driving rain may wet the platforms and inconvenience passengers. In the Havana station, the openings are about 28 in. wide, with walls nearly 10 ft. high and rising about 3 ft. above the roof. The columns and trusses are spaced 25 ft. longitudinally, and purlins upon the latter support a concrete roof slab. Between the inclined end posts of the trusses are fitted wire-glass skylights. Along the center of the roof are ventilator openings, 12½ ft. apart, each of which is protected by a low monitor of concrete, with side openings; these monitors are 4 ft. large. The clear height of the roof above the rails is about 14 ft. to top of columns, 20 ft. at center of truss span, and 16 ft. at edge of cantilever spans. The total length of trainshed is 500 ft.

FIELD AND OFFICE

Breaking Up an Old Cable Conduit

By C. M. Kurtz*

The work of converting the old Geary St. Cable R.R., in San Francisco, into an electric railway, to be known as the Geary St. Municipal Electric R.R., is now well under way. The cable road was originally constructed in 1888 and suffered but little, if any, damage from the earthquake and fire of 1906. At the expiration of its franchise, the road became the property of the city of San Francisco, and it is now being reconstructed under the direction of Marsden Manson, city engineer. The erection of the overhead system was completed a few months ago, and now (June 25) the operation of the cable road has been permanently discontinued so that the contractors may work uninterruptedly day and night.

The old concrete cable conduits and slots are being broken up by a drop hammer operated vertically in gins that are 15 ft. high, being short enough to pass under all the cross-line trolley wires. This rig is shown in the photograph, Fig. 1. It will be noted that the gins are framed to converging sills, and that the device is similar in construction and operation to the common skid pile driver.

In order that the hammer may do its work most effectively, the rails of the track are first taken up and a trench 1 ft. wide by 2½ ft. deep is advanced along the outside of the conduit, between the tracks, a few hundred feet ahead of the hammer. This trench is at the right of the conduit in Fig. 1. It serves to remove all lateral pressure that would tend to help the conduit concrete resist the breaking force of the hammer. The northerly track is being broken up first and the hammer is operated at intervals of about every 5 ft. on both sides of the slot, and at the yoke irons. Ten to thirty blows of the hammer break up the concrete and the basalt paving blocks cemented to the top of the old conduit and break the bond between the yoke irons and slots and the concrete.

When the work of breaking the conduit was started, the hammer shown in Fig. 1 weighed 3500 lb., but at the time the photograph was taken, after having broken up two miles of conduit, the hammer had lost some 400 lb. of its original casting, and its striking face had worn to a blunt edge, as shown in the illustration. The first experiment in this line was with an ordinary steam hammer, and it was clearly demonstrated that the short, quick blows were quite ineffective in breaking the concrete, but did considerable damage to the driving mechanism. A chisel point attached to the bottom of the drop hammer was also tried, but was found to be not as effective as desired and was abandoned in favor of the plain hammer.

At all pipe crossings, the pipes are uncovered in advance of the hammer and the conduit concrete in the vicinity is carefully broken up by laborers working with gads and 12-lb. hammers. Any possible chance of breaking the pipes by the operation of the drop hammer is thus avoided.

Following along on the broken-up track, a short distance back of the hammer is the stiff-leg derrick on skids shown in Fig. 2. This derrick has a short boom to allow operation under the trolley wires, and is provided with a trolley pole to hold the wire in the clear. It is designed for a safe load of 30 tons and is employed to tear up the yoke and slot irons and the larger pieces of concrete.

As the irons are lifted and torn from

Fig. 1. Drop Hammer Breaking Up the Concrete Conduit of an Old Cable Railway in San Francisco

Fig. 2. Derrick Tearing Out Cable Slot and Yokes
(The derrick follows the hammer shown in Fig. 1.)

*234 Iowa St., San Francisco, Calif.

the concrete, they are dragged to the curb on the side of the street kept open for traffic, to be subsequently carted away and sold for scrap. The larger pieces of concrete are placed in the gutter and roadway next to the track being torn up, to be subsequently broken by hand hammers into sizable pieces and passed through a traveling rock-crusher with the rest of the broken concrete. The output of the crusher is used as ballast for the new roadbed.

The concrete breaker is making a progress of about 600 ft. a day, working one 10-hour shift, while the derrick makes about the same progress, working three 8-hour shifts per day. Mahoney Bros., of San Francisco, are the general contractors for the construction of the roadbed and track, and the firm of Roberts & Harris have the sub-contract for taking up the old track and conduit and crushing the concrete.

Rapid Winter Work in Rebuilding the Bayless Pulp Mill at Austin, Penn.

During the past winter the old Bayless Pulp Mill, at Austin, Penn., which was wrecked by the flood of water when the Austin dam failed on Sept. 30, 1911, was replaced by a new structure 200x600 ft., of steel frame with tile walls, reinforced-concrete floors, and wooden plank roof covered with three-ply bituminous roofing coated with pitch and sand. Although the winter was one of the coldest in recent years, the entire mill was completed in 130 days. Jones, Beers Co., of Binghamton, N. Y., were the contractors. Boyle Irwin was their superintendent in charge of construction.

At the beginning of work the site was covered with wreckage of buildings and machinery, mixed with large quantities of pulp wood (from the piles which had been stored in the valley above the mill) together with a large amount of mud and miscellaneous débris. This had to be cleared away first. Most of the débris was removed by "snaking" out with a steel cable drawn by a small locomotive running on standard-gage track sidings, which had been relaid in their original positions on both sides of the mill. Small stuff was handled on horse-drawn "boats" (sleds). Then the concrete footings for the new mill were prepared. Many of the old piers, etc., had been destroyed or badly damaged by the rush of water, but various machine foundations, floors and walls, which had been built with a great excess of strength, stood the flood without much injury.

In making the wall and column footings, excavation was carried down below frost level and to a good foundation stratum, as rapidly as possible. Then the forms were erected and concrete poured at once. In placing interior column footings for the reinforced floor of the Wet Room, holes were cut through the old concrete floor of the original basement and fires built in them to take the frost out of the ground. This proved entirely effective in giving a sound foundation, which was not disturbed by thawing later; the thawing of the ground under the old floor let it drop 4 to 6 in. along the new concrete columns, the latter being unaffected.

Stone was quarried on the mountain-side near-by, and crushed there to the proper sizes for the concrete. At the building site a movable continuous mixer was used in making concrete, as there was much moving to do and with this arrangement the concrete could be poured soon after it was mixed.

Steam coils were placed in the stone bins at the crusher to keep frost out of the broken stone, and at the mixer steam coils of perforated pipe were put under the sand and stone piles. In addition, salt was thrown into the stone bin of the mixer. The mixing water was heated by turning steam into the lines, and the wheelbarrows were heated over fires, to help keep the concrete from chilling. In the middle of the day heating the water usually had to be stopped, to prevent excessive heating and consequent rapid set of the cement. With the procedure as adopted the concrete usually stayed warm enough when poured into the form to set in a normal time, and then if carefully covered at night it proved to be entirely safe.

All the footings of the outside walls and of two fire walls were placed in cold weather. A few small concrete piers and a short section of wall footing were frozen and had to be replaced. Replacing them was less difficult than might be expected, under the prevailing weather conditions.

The floors of the new mill are designed for a live-load of 600 lb. per sq.ft. Structural steel was sent to the job cut to length, and was fabricated at the site. The steel was rapidly erected by two small stiff-leg derricks, which were able to command the full width of 200 ft. and were moved longitudinally as successive bents were erected. The rapid erection of the hollow-tile walls did much to hasten the completion of the work.

The entire job of rebuilding the mill required about 18 cars of tile, 450 tons of structural steel, 600 M ft. of lumber, 400 bbl. cement, 1100 squares of roofing, 370 skylight lights, and 78 ventilators.

The present supply of power to the mill is from a timber crib dam about half a mile above the wrecked concrete dam. This dam has been reinforced by earth fill on the downstream side. During a freshet last spring the water behind the dam rose to the crest and overflowed about 5 in. deep. At that time the people living in the valley below were alarmed over the chances of a repetition of the previous dam failure, but the crib dam held safely and was not damaged by the overflow.

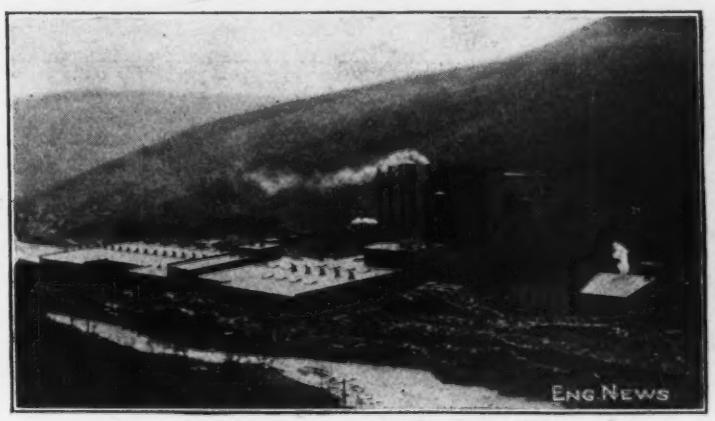


FIG. 1. LOOKING DOWNSTREAM ACROSS VALLEY

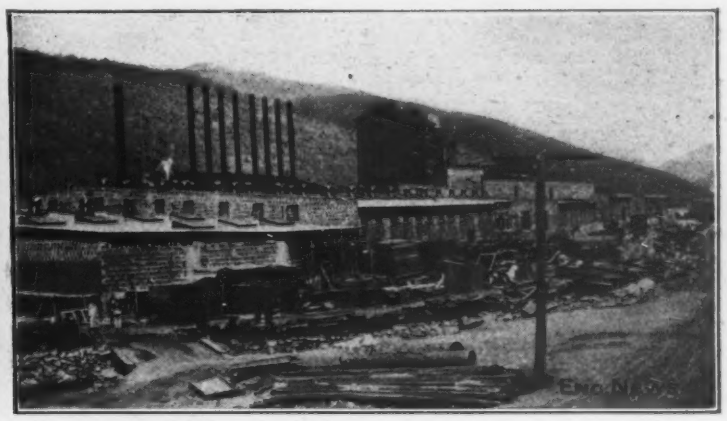


FIG. 2. NEAR VIEW, LOOKING UPSTREAM

NEW BAYLESS PULP MILL AT AUSTIN, PENN., REBUILT LAST WINTER IN 130 WORKING DAYS

(Size of buildings, 200x600 ft.)

House Painting Necessary—"Those who did not paint their houses and buildings in 1911, or have not done so so far this year, are advised that they have until July 15 to do so, after which date the Municipality will do the work and charge the cost against the property, with the possibility of a fine being added."—[West Coast Leader, Lima, Peru, June 19, 1912.]

Rapid Field Drilling of Rivet Holes on the Panama Lock Gates

Remarkably effective work has been done in the erection of the Panama Canal lock gates by special drilling machines for drilling the rivet holes in the plates. These machines work on erection platforms set up along the faces of the gate, and must meet the combined requirements of portability, ease of handling, and efficiency. The contractor for the manufacture and erection of the gate, the McClintic-Marshall Construction Co., had these special machines designed and built by the Foote-Burt Co., of Cleveland, Ohio. The two views, Figs. 1 and 2, herewith show one of the drills; Fig. 3 shows the drill mounted on the erection platform along the face of a lock gate at work drilling the rivet holes. These machines were first started in February, 1912, on the main gates of the upper lock, at Gatun. They were required to drill a 1-in. hole in 1-in. plate at full speed (280 r.p.m.) with maximum feed (0.051 in.), which means 14.3 in. feed per minute. This performance was successfully accomplished, the hole being drilled in 3½ sec. A 1¼-in. hole in 1-in. plate was drilled in four seconds. Sixteen of these machines have been installed up to the present.

The drill has two fixed spindles, 6½ in. apart, suiting the regular spacing of the rivet holes in the plates. The spindles may be seen in Fig. 2. The drill-spindle head can be raised or lowered by the upper handwheel acting through reduction gearing upon the raising screws; the head is counter-balanced, and has 48 in. vertical movement. The spindles have a power feed forward, with four feeds, provided by quick-change gears. A 16-in. length of feed is provided and either spindle can be fed independently, or both together. A quick-return motion is fitted. The spider handwheel (Fig. 1) returns the spindles after the power feed is disengaged by pulling out one of the four arms. The changes of feed are made by the small hand-lever seen through the main-hoist handwheel in Fig. 1. The spindle drive has 16 speeds, provided electrically through the controller of the driving motor, without any mechanical speed changes.

For traversing the entire machine, the machine is mounted on a four-wheel truck of 48-in. gage with roller-bearing axles. The inclined handwheel (Fig. 1) moves the machine along the rails. At the top of the machine a shackle is provided for handling the entire machine by a hoist block or derrick.

The following table gives some of the main particulars of the machines:

Gage of track	48 in.
Center distance of spindles	6½ in.
Extreme height of column	7 ft. 6½ in.
Extreme depth, back to front	46½ in.
Vertical adjustment of head	48 in.
Bearing of head on column	30x12 in.
Lowest working position of head above rail	20 in.
Highest " " " " " "	5 ft. 8 in.
Diameter of spindle, in sleeves	3 in.
at driving end	2⅞ in.
at nose	4¼ in.
Taper in nose of spindle	No. 4 Morse
Spindle speeds	140-280 r.p.m
Feeds	.01, .02, .035, .051 per rev. spindle
Length of feed	16 in.
Weight of machine	10,860 lb.

The drive of each machine is a No. 6 Westinghouse shunt wound motor of 10 hp., geared 2 to 1, with drum controller.

The conditions for which the machines had to be designed are severe. During the rainy season the atmosphere is constantly moist, while during the dry season dust and dirt have to be contended with. The machines must be operated by a low grade of labor, and thus had to be extremely simple in their operation, and proof against derangement. Being intended for working on the erection stagings, they had to be self-contained, able to take the working strains without overturning, and at the same time be kept light enough for handling by crane or chain hoist. The machines as designed and built appear to have met these requirements very satisfactorily.

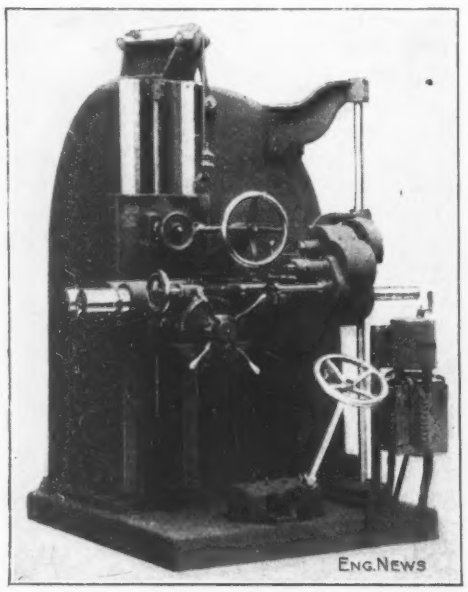


FIG. 1. WORKING SIDE

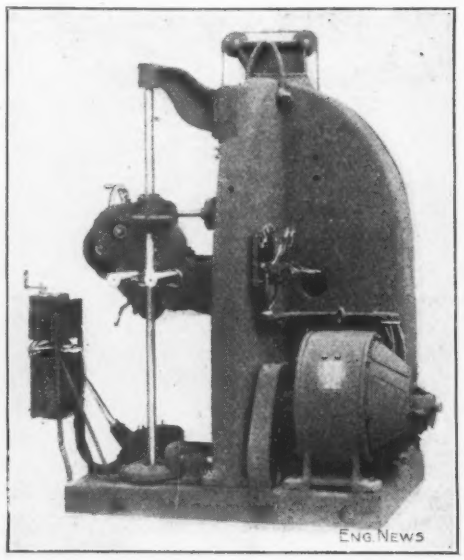


FIG. 2. FRONT OF MACHINE, SHOWING THE TWO DRILL SPINDLES

FIGS. 1 AND 2. SPECIAL SELF-CONTAINED DRILLING MACHINES FOR FIELD REAMING AND DRILLING, PANAMA LOCK GATES

(Designed and built by Foote-Burt Co. for McClintic-Marshall Construction Co.)

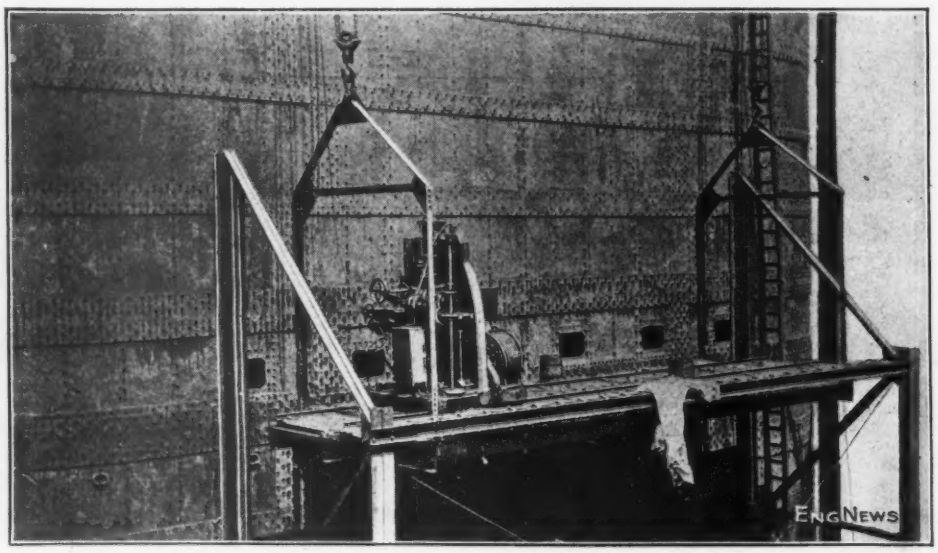


FIG. 3. VIEW OF DRILLING MACHINE ON ERECTION STAGING ALONG UPSTREAM FACE OF A GATE LEAF

Use of Loose-Leaf Note-Books—O. H. Tripp, of Rockland, Maine, sends us the following note in regard to loose-leaf note-books for use in the field:

I am using an "I. P." book No. 105, having three different sheets in the same book, viz, one for miscellaneous work, blank sheets for calculations, and sheets for level notes, each being separated from its neighbor by a pressboard leaf. I inclose sample sheets which will show perforations and rulings. The level note sheets are also used for cross-section work.

The sample sheets sent us are 4x6¾ in. and have the same ruling ordinarily found in the regulation surveyors' note-book.

Low-Cost Testing-Machines for Concrete Beams and Slabs

By Ernest McCullough*

A certain company manufacturing concrete products, making a specialty of roofing tile but undertaking anything for which blueprints are furnished, has to produce many odd shapes designed by architects. The writer proportions the reinforcement and assists in designing forms for this work. Many designs sent in by architects cannot be reinforced by calculation and it is necessary to make assumptions and test a number of specimens before the proper amount of reinforcing is fixed. This fact made it necessary to install a testing-machine.

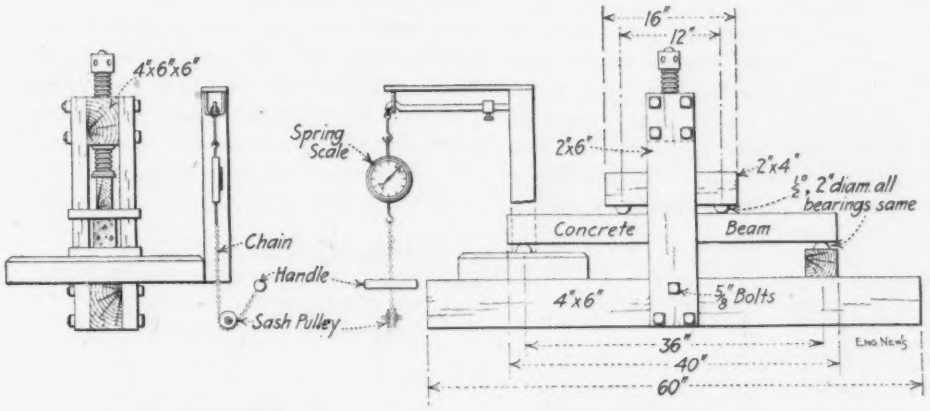


Fig. 1. Testing-Machine for Small Control Beams; Cost about $15

The standard products of the company also are now tested regularly. The effect of this practice upon the workmen is excellent. The standard tile are made by the piece, the workmen earning more in this way than they can earn at day wages. Each piece is stamped with a mark identifying the maker, and an inspector examines each piece before it is piled for curing. Pieces in the past have been broken from time to time, and when evidence of bad workmanship appeared the maker was disciplined. Since installing the testing-machine a number of pieces made by each man are tested at regular intervals, the man himself assisting in the tests. The uniformity in the product at present is little short of marvelous, whereas in the first tests there were wide variations, although all results were good.

To get compressive values of concrete, beam tests are better for practical use than crushing tests of cubes or cylinders. Compression testing-machines are expensive, and we wanted to spend as little money as possible. Therefore, a testing-machine for control beams was built, which answers all purposes at a low cost; it is shown by Fig. 1.

The platform scale can be purchased (without wheels) for less than $15. Its rated capacity is 600 lb. The screw-jack, wrought iron, is 1¼ in. in diameter by 12 in. long and cost $1.65; the nut block is reversed and screwed to the underside of the 4x6-in. wooden block held between the uprights. The four bearings may be of cast iron or may be cut from 2-in. iron or steel bars. The span of the beam is 36 in. c. to c. bearings; the load is applied at the third-points. The machine made as shown is strong enough to permit a breaking load to be applied to the beam, without any yielding.

The concrete beams tested are 3 in. wide and 3½ in. deep, the reinforcement being one ½-in. deformed bar. The depth to the center of the steel is 3 in., the position of the steel being accurately fixed.

The method for weighing the load, shown in the sketch, has proven to be practical. A piece of plank 2 ft. long has a seat at one end and a sash pulley at the other, a sash-weight chain passing under the pulley. When the beam to be tested is in position, the beam weight is moved along the scale beam until it balances. One end of the chain is then hooked to a spring scale hung on the end of the weighing beam, and the operator, seated to hold the plank down, grasps the handle on the other end of the chain. The laborers then begin applying the load, and, as the pull on the chain holds the scale beam balanced, the pointer on the circular scale indicates the load.

The deflection lever is not shown in the figures. At one end of the plank on which the operator is seated is an upright board with a scale at the upper end graduated in tenths of an inch. When in position this scale is at the height of the load-weighing scale, so that they can be observed together. On the face of the board two vertical lines of tacks, the heads projecting, make a channel in which a very thin piece of wood moves up and down freely. On one side of the bottom timber a light piece of wood (a lath) swings freely on a nail. One end touches the lower end of the upright on the scale board, the other end having a bent piece of wire which touches the bottom of the beam at midspan. The fulcrum nail is as nearly as possible halfway between the middle of the beam and the light upright on the scale board; the upright is pushed up as the beam deflects and its upper end indicates the deflection. While the device is not exact, we obtain the deflection and load simultaneously, and close enough for all practical purposes. When the steel begins to stretch the load indicator is stationary while the deflection increases rapidly.

Fig. 2 shows a large machine for testing the slabs and beams made by the company. The capacity is 20,000 lb. The small-scale sketch in Fig. 2 shows a 16-ft. slab in place; the arrangement of lever beams shown was rendered necessary by the fact that the platform scale has a capacity of only 1000 lb. and is in daily use in the factory when not employed for tests.

Load is applied by means of the 40-in. wheel at the upper end of the screw. One man can apply the load, but two are used to secure a slow uniform movement, one man being apt to cause measurable impact. On another similar machine the writer will dispense with the large wheel and use gear and pinion fastened to one of the standards, with shaft and worm just below the upper cross-bar. One man can then apply the load at a uniform rate. The cost of this testing-machine complete should ordinarily not exceed $80.

The concrete base, 12 in. thick and 4 ft. wide, contains two 7-in. I-beams projecting about ¾ in. above the surface of

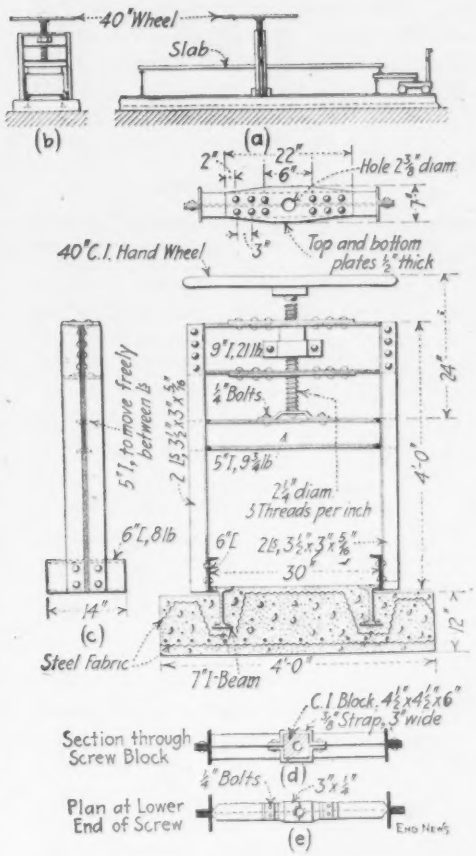


Fig. 2. Testing-Machine for Slabs Up to 2½x16 ft.; Cost about $80

*Consulting Engineer, Monadnock Block, Chicago, Ill.

the concrete. The beams are 18 ft. long (simply because the company had two of that length on hand and it was thought some 16-ft. slabs might be made).

The 6-in. channel sections hook under the I-beam flanges and wooden wedges are put in to hold the yoke in position. Holes were drilled in the lower flanges of the I-beams, 24 in. c. to c. staggered, and ½-in. bolts put through, to assist in holding the beams in place; this is really an unnecessary feature, but the holes were there and the bolts were handy.

Ordinarily one end of a slab rests on the platform of the scale, the spring scale hung on the scale-beam registering one-half the load. The spring scale used weighs to 24 lb. by tenths of a pound. The ratio of levers in ordinary platform scales being 1:100, one-tenth pound on the spring scale represents 10 lb. on the platform, and the platform load is one-half the total load. By using timbers and small I-beams as levers any desired multiplication may be used.

A slab too wide to go between the uprights has been tested by placing it on supports on one side the frame, the scale being set on the opposite side. A strong timber extended from the middle of the slab to the scale, the load being applied at a point one-third from the end, as the capacity of the scale would have been exceeded had the load been applied in the middle of the timber.

Deflections on the large machine are obtained by a lever arranged as already described for the small machine. The ratios, however, are not always equal, being sometimes 1:5 and sometimes 1:10. To avoid multiplication the scales are exaggerated an equal amount. The deflection scale is on heavy paper held in place by a thumb-tack, which affords a simple adjustment.

Precise-Levels in New Jersey—A line of precise-levels was run in southern New Jersey in 1911, connecting a number of benchmarks which had been determined in 1880 and 1886. The results are summarized in the following table, given in the 1911 report of the State Geologist (H. B. Kümmel, Trenton, N. J.:)

Benchmark	Elevations 1886	Elevations 1911	Difference
Cape May, Courthouse	19.498	.....	.....
Sea Isle City	9.151	9.033	—0.118
Millville Natl. Bk.	33.450	33.453	+0.003
Vineland, West Jersey Station	108.10	108.082	—0.018
Mays Landing, Court-house	19.89	19.790	—0.100
Absecon, M. E. Church	30.660	30.638	—0.022
Atlantic City, Absecon Light-house	8.954	8.931	—0.023

The survey was made under the direction of C. C. Vermeule, who concludes as follows:

It will be seen that the agreement between the levels of the present year and the original levels of 1886 is extremely close and entirely within the probable error of the observations. The agreement throughout is such that it may be assumed that there has been no important relative change of elevation between these several benchmarks during the interval from 1886 to 1911.

A Large Timber Bulkhead Under 168-ft. Head

By Arthur W. Tidd*

A number of valleys are crossed by the aqueduct for the new water supply for New York City (now under construction), in the course of the 92 miles from the Ashokan reservoir in the Catskill Mountains to the Hill View reservoir at the New York City line. One type of aqueduct for such crossings is a line of riveted steel pipe laid across the valley at the surface of the ground. The pipe line is laid directly down the slope to the bottom of the valley and up the opposite slope to the hydraulic gradient, connection at either end with the cut-and-cover type of aqueduct being made through a siphon chamber at grade. The specifications require that after the steel pipe has been laid and riveted, it shall be filled with water to the hydraulic gradient, thereby putting it under normal working pressure, and that said pressure shall be maintained until the pipe shall have been caulked and the protecting envelope of concrete placed around it.

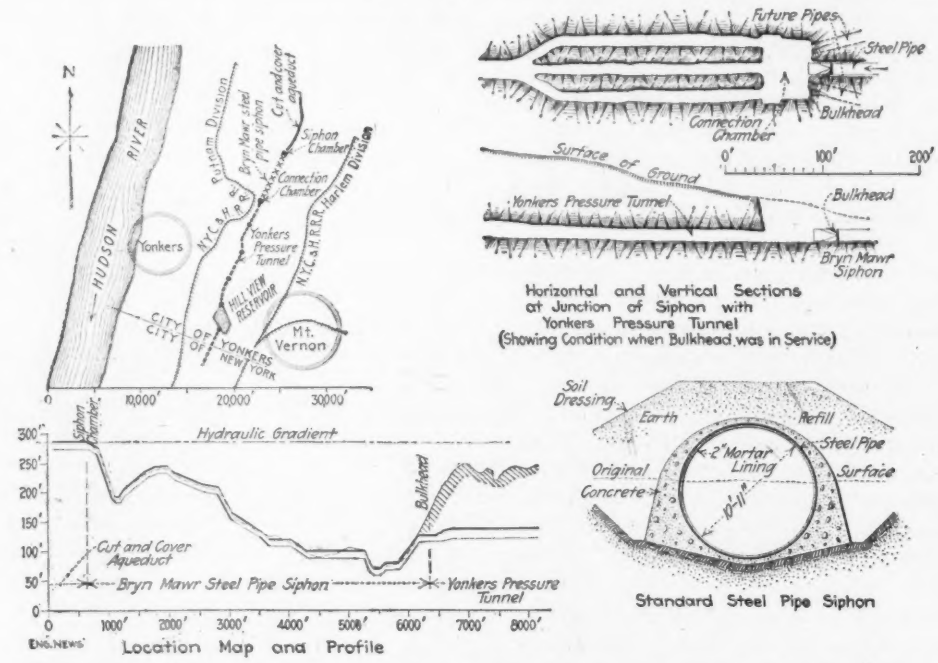


FIG. 1. LOCATION, PROFILE AND SECTIONAL SKETCHES OF BRYN MAWR SIPHON, CATSKILL AQUEDUCT

(At the connection of the siphon with the Yonkers pressure tunnel a temporary timber bulkhead for 168-ft. head was used).

Before the pressure can be put on, it is necessary to build a temporary bulkhead in each end of the pipe. Ordinarily the bulkhead is only a few feet below the hydraulic gradient, and therefore does not require heavy construction. In one case, however, the steel pipe terminates near the bottom of the valley, where it enters a pressure tunnel, and the bulkhead at that point had to withstand a head of about 168 ft. on the center. This is at the Bryn Mawr siphon, 11 ft. 3 in. in diameter and about 6000 ft. long, located some four miles north of the northern limit of New York City.

Fig. 1 shows the general location, a profile of the siphon and sectional sketches. As may be seen in one of the sketches, the aqueduct is continued beyond the pipe in a tunnel, which is normally 16 ft. 7 in. in finished diameter, but which for about 275 ft. at this point is divided into three branches each 10 ft. in diameter. The branches are to provide connections for the complete installation of three lines of steel pipe, though only one pipe is being built at present. At the time the bulkhead was in service, the pipe terminated in the deep portal cut with only about 48 ft. intervening between the open end of the pipe and mouth of the center tunnel. The three branch tunnels and the main tunnel were excavated and open through to Hill View reservoir, but during the 2½ months that the bulkhead was in service, work was being actively prosecuted in the tunnel under another contract at many points, several gangs of men being at work near the portal and in the portal cut itself. It was necessary therefore to take every precaution against the possibility of the failure of the bulkhead, since 2,000,000 gallons of water in the pipe would have been released, with a theoretical velocity at the first rush of over 100 ft. per sec.

The total load to be carried by the bulkhead was about 529 tons. The contractor made a design for a wooden bulkhead held in place by steel I-beams and angles and timber braces. The bulkhead was built as designed, and the work was done so thoroughly that the leakage amounted to only about 5 gal. per min.,

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*Asst. Engr. Board of Water Supply, New York City; 215 Kimball Ave., Yonkers, N. Y.

and at no time was there any outward indication of strain. When it was taken down, a well defined mark was visible where the timbers rested against the circumferential 6x6-in. angle, but elsewhere there were no evidences of distress. Fig. 2 shows sketches of the bulkhead.

The bulkhead was built up, beginning on the outer or dry side, of two 6-in. thicknesses of 6x8-in. timbers placed horizontally one on top of another, two thicknesses of 2-in. plank placed in opposing diagonals, and one thickness of 2-in. plank placed horizontally; the total thickness from the dry side to the wet side was 18 in. The timber was yellow pine throughout. The 6x8 timbers were beveled on the water side to make a calking joint about ⅜ in. wide at the face and about 3 in. deep. This was filled by driving a small amount of cotton batting into the bottom of the joint, then oakum to within about ½ in. of the face, and then the remaining space throughout pointed with neat portland-cement mortar. The 2-in. plank (shiplap) had its joints calked on the inner or water face, as described. The inner face of the inner thickness of 6x8 timbers and the inner face of the outer thickness of 2-in. plank were painted with coal-tar paint. The circumferential joint between the ends of the three thicknesses of 2-in. plank and the steel pipe was calked with cotton batting as each layer was put on; only the inner thickness was pointed with cement. The two thicknesses of 6x8 timbers were spiked to each other and to the 6x8 uprights with 10-in. boat spikes, and the three thicknesses of 2-in. plank were spiked with 5-in. wire spikes.

The load was transmitted to the steel pipe through the following system: A circumferential 6x6x¾-in. angle was riveted to the pipe with seventy-six 1-in. rivets, against which the outer thickness of 6x8 timbers abutted. The face of the bulkhead was held directly by five uprights, three of which were 6x8-in. timbers and two were 15-in. by 60-lb. I-beams, bearing at midheight against a horizontal 20-in. by 80-lb. I-beam. The two vertical I-beams abutted at each end against a 6x6x¾-in. angle 2 ft. long, riveted to the steel pipe with thirteen 1-in. rivets. The horizontal 20-in. I-beam abutted at each end against a like angle, fastened in the same way. From the center of each of the two vertical 15-in. I-beams two 6x8-in. timbers about 15 ft. long extended respectively to top and bottom of the pipe, footing against a similar 2-ft. length of 6x6-in. angle. From the center of the 20-in. I-beam two 6x8-in. timbers about 13 ft. long extended in the horizontal plane to either side of the pipe where they each footed against a like angle lug, and each of these lugs also held a 6x8-in. timber about 12 ft. long, extending from the end of the 20-in. I. The four short 6x6-in. angles against which the eight inclined braces footed were in the same plane, normal to the axis of the pipe, and located at the ends of the vertical and horizontal diameters. To prevent deformation of the steel pipe by the outward thrust of the braces, two steel tie-bars, 4x1 in. by 11 ft. 3 in. long, one vertical and one horizontal, extended across the pipe and were riveted to these angles with two 1-in. rivets in each end of each tie-bar.

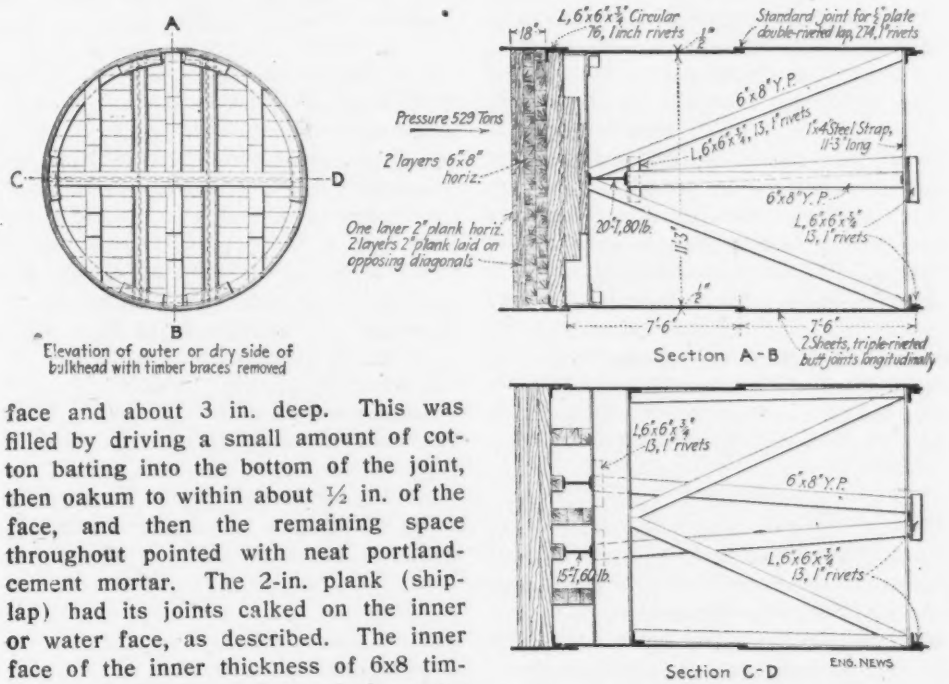


FIG. 2. TEMPORARY BULKHEAD FOR 168-FT. HEAD, AT SOUTH END OF BRYN MAWR SIPHON

The distribution of the load among the different members is indeterminate but an ample factor of safety was provided, which, of course, should have been done considering the number of lives that would have been lost if an accident had occurred. The workmanship was excellent throughout, all braces being cut to fit and very few wedges used or required.

As a safeguard against possible ignorant tampering with the bracing or bulkhead, the end of the pipe was boarded over and a door with a padlock provided for gaining an entrance. A careful daily inspection was also made, but no weaknesses or leaks developed, nor were any repairs required at any time.

Difficulties in Constructing the Little Rock Southern Ry.

BY J. M. STARK

The Little Rock & Southern Ry. was chartered in Arkansas as a branch line of the Chicago, Rock Island & Pacific Ry., over which the latter expected to reach New Orleans. The line began at Haskell, 27 miles from Little Rock, and extended southeast to Crossett, 108 miles, with a branch from Tinsman to El Dorado, 36 miles, making the total distance of 144 miles. The main line was located on a grade of 0.3% and maximum curvature of 2°, except one 3° curve. Only 8% was on curves. The branch was on a maximum grade of 0.6% and maximum curve of 3°, with only four 3° curves and only 12% of the line on curves. These grades and curves would indicate an easy country, but required some very heavy work in several places.

The entire line, with the exception of an occasional cultivated field, was through timber; the higher grounds having mostly pine, and the bottoms having oak, hickory, gum and other hardwoods. The only towns touched by the entire line were Fordyce, Crossett and El Dorado, and these were the only places accessible by rail. The line crossed only two important streams: the Saline River, on the main line, and the Ouachita River, on the branch. Both of these, being navigable rivers, required draw spans. Besides these, there were a great many small streams, most of which had low, wide bottoms that would overflow on the slightest provocation. Very few of these streams had wagon bridges; and, as a result, it was often necessary to swim the streams or make a detour of from 10 to 15 miles in getting over the line.

ORGANIZATION

The contract for the entire line, including clearing, grading, timber bridging, and tracklaying, was awarded to Craney, Dalhoff & Peters about Mar. 25, 1905, and stipulated that work was to be completed by Dec. 31, 1905, giving nine months to organize both engineering and contracting forces and complete the entire line. The writer received instructions, at the time the contract was awarded, to cover the entire line with engineers as quickly as possible, so that any and all parts of the line would be ready for contractors as fast as they could move on to the work.

The line was divided into three divisions of 50, 58 and 36 miles, requiring three division engineers. The divisions were subdivided into residencies of 9 or 10 miles each, requiring 15 resident engineers, with a rodman, tapeman, axman and cook for each. Owing to the country being sparsely settled and none of the

*Abstract of a paper in the Transactions of the Engineering Association of the South, 1911.

farmers being prepared to furnish either board or lodging for a party, all resident engineers, except one, had camps. It was our policy to fit up these camps as comfortably as possible, in most cases putting floors in the tents and putting in screen doors to keep out mosquitoes and other winged insects that made night hideous to men in a tent without such protection.

By the middle of April we had the engineering forces organized and on the ground. We had to make one change of line for 15 miles; and as our men arrived, we put them on this relocation until we could get them distributed on their various residencies. While this location was going on, we were able to form an opinion as to the qualification of the various men and to place them to the best advantage.

The approximate quantities to be moved were about 3,500,000 cu.yd. It had been figured that from 600 to 800 teams would be ample to complete the work in the specified time, but in this case the figuring was very far from accurate when applied to Arkansas without a provision as to the weather. By the end of April the contractors had 180 teams on the work, and in May they increased their forces to 459 teams; and June showed a force of 611 teams; July, 721; August, 759; September, 838; October, 943; November, 1110; and December, 1311. There were six grading machines on the work, and one steam shovel hauled in to a big cut 20 miles from a railway. The forces would have been larger early in the season, but the continued rains kept contractors away from the work.

Construction

The organization started out in fine shape and bade fair to make rapid progress with the work. The starting of the work, however, was the beginning of our troubles. April was a month of almost continuous rains and high waters, and the succeeding months seemed to try to keep up the record set by April. The old citizens declared they had never seen so wet a season.

We were fortunate, however, in having subcontractors with grit, as not one of them left the work until they finished the work they undertook to do, though they were nearly all losing money. They continued to move from one point to another in the hope of finding a place dry enough to work. This process was continued until a large part of the work was opened in spots and none of it could be finished. By continued ditching they were able to work a day or two in one place, then would have to move and do more ditching. Ditches, however, in many cases would not draw the water more than a foot or two through the clay, and eventually it had to be taken out as mud. It was a daily occurrence in almost every gang to get mules bogged down and have to hook on other teams to them to pull them out.

The feature that surprised us most was that the highest ground was equally as boggy as the low ground. The surface of the country generally was of a sandy, loamy nature for a depth of from 2 to 5 ft., underlaid by clay that held water like a jug; and with the top layer saturated, there was no way for the water to escape except by evaporation. With these conditions existing, we had a continual fight against mud and water; but by persistent work, making ditches wherever possible to draw off some of the surface and seepage water, we succeeded in narrowing the work down to short stretches at different points where it was impossible to get teams on the ground.

As we crowded these points with track, it became a question of holding up track indefinitely or devising some plan to get over with track and do the grading later. In many places we lowered the grade temporarily from 2 to 10 ft., and filled in and raised tracks by steam-shovel work after track was laid. At other places we put in temporary trestle, and in others we "shooflied" cuts with track and put in steam shovels. We treated in this way 4 miles of temporary grades on fills and raised track later, 4½ miles of cuts that were shooflied (track laid over the cut), and 4½ miles of temporary trestle driven and filled in with steam-shovel work.

Trestles

These trestles were not confined to creek bottoms, but many of them were on low, sloping ground; but owing to wet conditions it was impossible to borrow from the sides or haul from cuts. For our temporary trestles we usually drove three-pile bents, using any kind of timber that could be got contiguous to the openings. For caps we used any kind of timber, simply hewing two sides to 12-in. thickness and drifting them to piles, as for permanent trestle. Where the piles were 10 ft. above ground or over, we sway-braced with poles of pine or such timber as was most convenient, spiking them to piles with boat spikes.

For decking we used standard 30-ft. stringers 8x16 in., using four to the panel, and putting in a drop bolt at one end to keep them from sliding. We made the panels 14 ft. instead of 15 ft., so as to give the stringer a lap across the cap at each end. They were not butted together as permanent deck, but lapped by each other on the cap. In this way we did not have to cut any stringers; and when we filled the trestle and took out the stringers, they were good for permanent trestles and could be framed as required. For these trestles we selected sawed track ties in order to get good surface for the rails. For guard rails to keep the ties from bunching we used strips 1x6 in., nailed to each tie with heavy wire nails. When the trestles were filled, the only timber recovered was the stringers; and, with this in view, we used the cheapest of timber for all other parts of the structure.

For all of these temporary trestles and steam-shovel work we made supplementary contracts at practically the same prices as the original prices. In some cases we hauled the dirt to fill in the trestles a distance of 12 miles. Most of the time the contractors used two steam-shovel outfits on this back work. One 65-ton shovel was used in the lighter material and short hauls, using 24 side-dump, 6-yd. cars, and usually two locomotives. The other outfit used a 90-ton shovel and 15 side-dump, 12-yd. cars and two locomotives.

River Crossings

The bottom at the crossing of Saline River was four miles wide and 8 to 10 ft. under high water. This required 4500 ft. of temporary trestle and 4800 ft. of permanent trestle and one 257-ft. draw span. The pivot pier was located in the west edge of the river, and consequently in low water half of the span is over dry ground. This was made necessary by reason of the crossing being in a sharp bend of the river, and we had to give the full width of channel in order to allow boats to make the turn. The Saline River is classed as navigable, but in my four years' acquaintance with this part of the river I have never heard of anything going up or down larger than a barge of staves or a raft of logs.

The pivot pier was made of concrete, using gravel from one of our pits 20 miles distant. This gravel did not require screening, as it had no dirt and contained about enough sand to make good concrete. Owing to high water we could not get the pivot pier in before track was laid, and in order to keep a channel open for large rafts we put in a temporary 44-ft. deck girder, on pile piers, over the channel, and a 40-ft. deck girder over the site of the pivot pier. There were about 800 cu.yd. of concrete in this pier, which cost about $15.50 per cu.yd.

The bottom at the crossing of the Ouachita River is five miles wide in extreme high water, three miles being from 15 to 25 ft. under high water. The concrete pivot pier for the draw span was built with river gravel, brought to the site in barges from a point seven miles upstream. The cement was hauled from El Dorado in wagons, 13 miles. The work of procuring gravel and getting sheet piles driven and excavations made covered a period of eight months owing to the frequent rises in the river during the summer of 1906, which made it necessary frequently to pay for labor when not at work in order to hold the men. When finished, the pier contained

about 1400 cu.yd. of concrete, the cost being about $22 per cu.yd.

At the north side of the bottom, where the ground was from 3 to 6 ft. lower than nearer the river, we put in 5300 ft. of permanent trestle adjoining the 4700 ft. of temporary trestle, which was later filled by steam shovel. The channel proper was spanned by one 354-ft. draw span, with an approach on the north of 155 ft. through span, and, on the south, one 60-ft. pony truss. On the north approach we had 2400 ft. of permanent pile trestle, and, on the south, 1200 ft. of permanent trestle.

During the entire year of 1905 the bottoms were overflowed so much of the time that we were unable to make much progress on this work, and it was January, 1906, when we began driving piles from the north side of the bottom, using a steam overhead driver. Much of this driving was done in from 5 to 10 ft. of water, using boats to float piles to the driver. We completed the driving of all the piles, including falsework for the spans, Nov. 2, 1906.

We reached the trestle with track in October, and worked all the forces possible on decking in order to get track out to the spans, so as to get them erected before high water, which was due, according to old settlers, in January or February. Precedent and old settlers' records, however, were washed out of existence by unprecedented rains about Dec. 18 and 20. On the night of Dec. 21 the water reached a height of 30 ft. above low water, and formed a heavy drift jam against our falsework; this took out 150 ft. of falsework, including the north rest pile pier for the draw span. During the next few days 150 ft. more of the falsework was taken out. This was a hard blow, as we had our erecting gang on the ground and were just ready to begin the erection of the steel. The water remained at such a high stage that we were unable to begin redriving until the latter part of January.

The washout was caused by the heavy jam of drift forming an under-current at the north side and scouring out the sand bank from 10 to 15 ft., thereby loosening the piles until they went over with the weight of drift. Many of the piles were broken off. This, doubtless, could have been avoided by cutting out three or four bents of falsework before the drift began to run; but the rise was so sudden that no time was given for consultation, and the man in charge at the river, while believing that was the proper thing to do, did not wish to assume the responsibility without instructions and so took chances and lost the falsework. Thus the work was delayed from Dec. 21 to May 8, at which time we had the falsework redriven by a track driver, and the spans all erected to resume tracklaying. We reached El Dorado with track on June 9, 1907, 18 months after contract time.

Grading and Ballasting

The first 20 miles from Haskell was very light work, but very flat, and water stood on a great part of it; and only by continued ditching were we able to get the grading done by October, 1905. However, we were able to start tracklaying the latter part of October. We were delayed a great many times for a few days by running on to unfinished grade, and at such times we used the tracklaying forces for cribbing up track to enable work trains to get over.

On Mile 23 we had a cut 45 ft. deep through a ridge. A steam shovel was hauled by wagon 22 miles over very muddy roads to take out the cut. They made two runs through the cut, taking about 15 ft. in depth each run, then started on grade to take out the bottom. When about 100 ft. from the end of the cut, there was a break 110 ft. back from the slope stakes and 200 ft. parallel to the center lines. This was not a slide, but the entire mass settled bodily, about 2 ft. the first night, and the roadbed that had been taken down to grade bulged up. As we took the material from the center, this mass on the side continued to settle. We found that by raising grade about 5 ft. we could get through the cut without the settling of this mass and raising in the center. In order not to hold up tracklaying indefinitely we raised the grade; and after track was laid, we put in a steam shovel and took out practically all of this material that was broken loose before we could lower track to grade. There was evidently a quicksand bed underneath; and as the weight was taken off through the cut, it was thrown out of balance, and the heavy end went down and the light end came up.

Our first gravel pit for ballast was on Mile 6; and as soon as we got 10 miles of track laid, we began hauling gravel and ballasting. The contractors laid skeleton track, and the ballasting was done by company forces. Owing to the wet season and the soft roadbed, both in cuts and fills, the ballasting was rather expensive, as it required going over so often before getting a bed of gravel that would hold. We put from 4 to 24 in. of gravel under the ties. From this first gravel pit we covered the first 50 miles. Our next gravel pit was on Mile 75, and from this we covered the second 58 miles. Our third pit was on Mile 6 on the branch, and from this we covered the 36-mile branch. The ballasting was not completed till August, 1907. The filling of temporary trestles was not completed until February, 1908.

Labor

The labor question was a very serious problem, as we had to ship in great numbers of men from Wichita, Kansas City, Fort Worth, and other labor centers. After shipping them this distance, we could not get more than one-tenth of them to work a day, many of them because of the mud and water, and many of them were just traveling and not wanting work. We tried Italian, Greek, negro, and white labor, all of which proved unsatisfactory, as they would only stay a few days. We finally made arrangements for 100 convicts, and worked them at putting under gravel, ditching, and tracklaying. They gave us the most satisfactory labor of all that we tried, principally because they could not quit.

A Wedging Blueprint Hanger

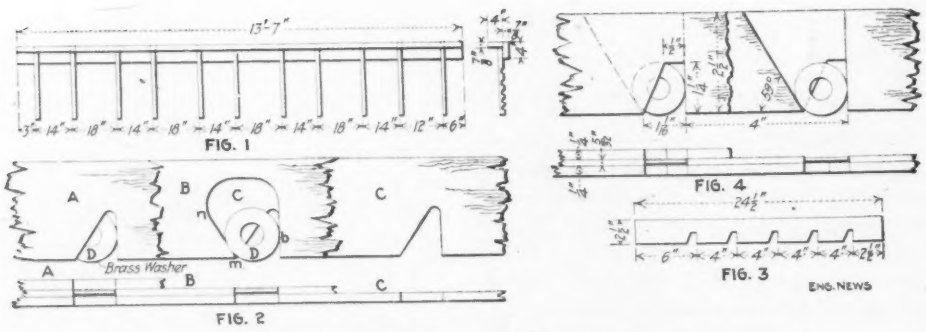
By A. Lewis Jenkins*

Facilities for hanging blueprints for drying are frequently overlooked. It is not unusual to find a good printing outfit without provision for drying the prints. Wires or sticks are sometimes used, causing objectionable folds and wrinkles in the prints, which render them difficult to trim and file. Another simple appliance frequently used consists of a number of clips, resembling ordinary spring clothespins, strung on a wire; in order to hang a sheet, say 24x36 in., which requires the use of both hands, the clips are most conveniently opened with the teeth, but usually no one person is given the exclusive right of biting them. Also, the clips, instead of remaining distributed along the wire, accumulate or bunch together, unless precautions are taken.

The patent hangers sold by dealers in drafting supplies are quite satisfactory, except for the price, which prohibits their use in many places. They are of good design and well made, with many highly-finished metal parts and woodwork of good material and workmanship, all of which justifies the price but makes them too costly for use in many places where they are needed.

In equipping our blueprint room, we wanted a hanger that could be made by an ordinary carpenter in a very short time. We designed one having clamp bars projecting from a wall strip, as shown in plan and side elevation in the sketch, Fig. 1, herewith. The first design for the bars was as shown in Fig. 2. Each bar consists of three thicknesses of wood, and five standard washers for a ½-in. bolt (⅝-in. hole). A complete side view of the bar is similar to that in Fig. 3. The pieces *A* and *C* are alike and made of oak, 2½x¼x24½ in., by cutting notches spaced 4-in. pitch. The piece *B*, which fits between *A* and *C*, is made slightly thicker than the washer (about 1/32 in.), and so cut as to allow the washer to be forced clear of the space formed

*Assistant Professor of Mechanical Engineering, University of Cincinnati, Cincinnati, O.



SKETCH AND DETAILS OF WEDGING HANGER FOR BLUEPRINTS
(A. L. Jenkins.)

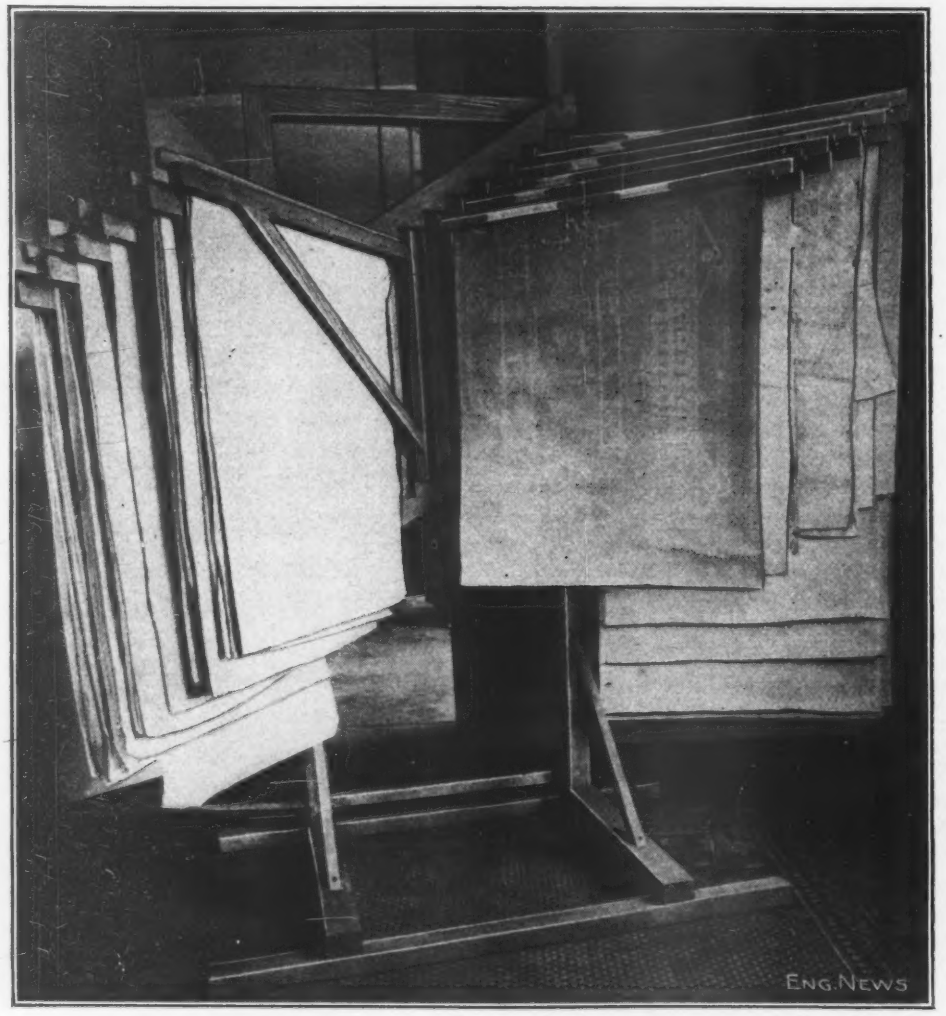
by cutting the notches in *A* and *C*. The sloping side *nm* of the slot in *B* causes the washer to press against the opposite side *b;* the wedging action is the stronger the steeper the slope of *nm*. A piece of paper placed between the washer and the wood at *b* and pulled downward will tear before it will slip out, provided the angle between side *nm* and the vertical is less than twice the angle of friction. It should be about 31°; a smaller angle causes the washer to grip the paper so tightly that it is necessary to raise the washers by hand to release the print, and if made greater, it is liable to not hold satisfactorily. It is desirable to have the angle such that it will hold the print and also allow it to be easily removed when dry by pulling slightly to the side without touching the washers by hand.

Iron washers were thought to be objectionable on account of rust, and most of the washers used were brass; but the iron washers after being in service for a year are in good condition; and there is apparently no reason why they should not be used.

The time and skill required of a carpenter to make the piece *B*, in Fig. 2, led to a change of design, shown in Fig. 4, the middle thickness of the bar being made of a number of separate pieces. The bar is put together with brads. That shown in Fig. 2 is best if glued; it is preferable to the later design on the score of strength and better appearance, but it is too expensive.

The wall of the blueprint room is 17 ft. 7 in. long. The spacing of the bars shown in Fig. 1 was thought best for hanging prints of any size which we might wish to make. Each bar has five grips. Bars having only one grip may be placed on walls in drafting room, office or shop where it is desired to hang drawings without defacing the walls or the drawing with tacks.

This hanger is particularly well adapted to hanging large charts and maps.



READY REFERENCE BLUEPRINT RACK USED AT NEW YORK NAVY YARD

Blueprint Rack and a Negative Filing System—The standing rack for blueprint filing which is shown in the photographic view below, is used by the public works department of the New York Navy Yard. Herman Block, of that department, to whom we are indebted for the photograph, says this rack has proved most convenient for filing active sets of plans bound and hung up for ready reference. The rack has about a dozen swinging arms which allow free access to the prints. A title card for each set of plans is pasted on the wooden strips used for binding the prints. The binding strips project beyond the prints at both ends and the projecting ends are placed on brass hooks screwed into the arms of the rack. The arrangement of the arms in echelon leaves all the titles visible at once.

Mr. Block also describes a system for filing photo negatives which has given satisfactory results in connection with the drafting-room work of the Navy Yard public works department. All negatives are marked with file numbers, serial negative numbers and titles (the same as drawings), using the same file number for the same subjects as are used on drawings. Each negative is filed in a paper envelope which has printed on one side a form to be filled out, giving the information before mentioned. A cabinet in the vault is divided into sections and the negatives are filed consecutively according to their file numbers, there being two or more file numbers in each section. The file numbers are marked immediately below each section, and a card-index system is used for indexing negatives, this index being arranged much like the standard correspondence file index.

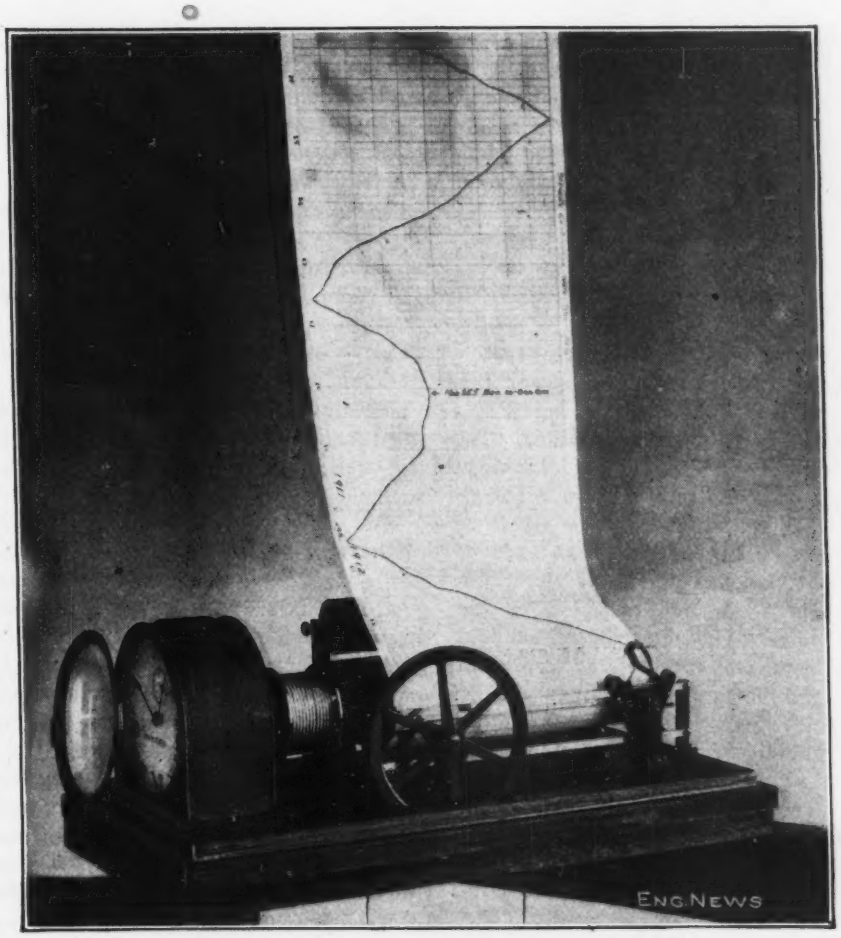
A New Continuous Water Stage Recorder

BY J. C. STEVENS*

The novel feature of the water-stage recorder shown in the accompanying illustration is that it can accommodate almost any range of stage without reducing the scale of the records. This is accomplished by means of a specially designed pencil carriage. When the pencil reaches either margin of the paper, its direction is suddenly reversed. In this manner a rise, or fall, of any magnitude is condensed on a narrow strip of paper, without reducing the scale. This gives in effect a folded record.

Distinction between rising and falling water is readily made from the fact that a cusp in the record on a rising stage must be repeated at the same stage when

*Formerly District Engineer of the U. S. Geological Survey, Columbia River District. Present address care of Ebro Irrigation & Power Co., Barcelona, Spain.



STEVENS CONTINUOUS WATER-STAGE RECORDER

the water falls. This is shown in the diagram or record slip in the accompanying illustration, which has been removed from the second roller of the instrument and straightened out to show the record line.

Another point of interest is that this instrument can be made to run without attention for almost any desired period. As supplied it will run two months without rewinding. If necessary the time of run can readily be doubled or trebled by increasing the driving weight and reducing its speed of travel—a change which can easily be made in the field.

The clockwork is driven by means of a weight attached to the cable wound on the drum shown in the illustration near the left of the record-paper roller. The record sheet is driven by this weight, acting through clockwork, at a uniform speed of $\frac{1}{10}$ in. per hour. A marking pencil is made to move at right angles to the direction of motion of the paper by means of a float and counterpoise.

The gage-height scale can be anything desired, but is made preferably some multiple of $\frac{1}{2}$ in order that feet of stage may be recorded as inches of record. The whole instrument is inclosed in a waterproof metal case, not shown in the illustration, and the clock is separately inclosed in a dustproof case of its own to avoid difficulties which would otherwise be likely to arise in the arid regions. The record form is printed on tracing paper and is supplied in 25-yd. rolls 11 in. wide. One roll is sufficient for a year's records. The record and the blueprints made from it can be folded to letter size for filing.

This gage was designed by the writer as the result of a long-felt want, originating during his former connection with the water resources branch of the U. S. Geological Survey. It has recently been placed on the market by Leupold & Voelpel, of Portland, Ore.

Short - Base Triangulation Methods on Reconnaissance and Exploratory Surveys

BY D. L. REABURN*

The method of short-base triangulation can often be used to great advantage on rapid surveys, either as a control for stadia readings or (where great speed and economy are desired) as the primary method for obtaining distances. The method consists essentially of the measurement of the angle at the instrument subtended by the lines of sight to two signals at the ends of a short measured base erected at a prominent point along the route of survey and as nearly as possible at right angles to the line of sight.

It is especially well adapted to traverse work, as a check, or in taking distances beyond the reach of the stadia; to the work of ranging out lines in rough country, such as boundaries, section lines, etc.; and to reconnaissance and exploratory surveys. It is applicable to both transit and plane-table work.

TRANSIT SURVEYS

On transit work the horizontal angle subtended by the two base signals is measured by the method of repetitions. Under favorable conditions a good 30″ transit should give the angle within 15″ by a single reading or within 5″ by six repetitions, three with telescope normal and three with telescope reversed.

To obtain a certain degree of accuracy in the resulting distance, the length of base should conform to the precision attainable in the angle measurement and the magnitude of the distance to be determined. Suppose for example that the signals have been properly set, and the base carefully measured so that there can be no appreciable error from that source, and that a distance of one mile is to be measured from readings on a 100-ft. base. Assuming an error of 5″ in the angle, the probable error in distance would be 5 in $\frac{100}{5280 \sin 1''}$ or one in 781.

This method was used by the writer in 1903 and 1904 on the Rocky Mountain and Cascade sections of the United States and Canada Boundary Survey for obtaining distances on the random-line work. The lengths of sight varied from 2 to 10 miles, and the bases were from 100 to 500 ft. long. Angles were measured with a high power 10″ repeating theodolite with probable errors of about 1″. The distances thus obtained were used in fixing temporary points on the true line, and as a control for the stadia profiles. The results when compared later with the primary triangulation showed an average discrepancy of about 1:2000. Reciprocal vertical angle readings were also taken to targets nailed to the signal poles and some remarkably close checks in elevation were obtained. The base readings were sometimes taken on the foresight and sometimes on the backsight, depending on the local conditions for establishing a base.

The principal advantages of this method of measurement as compared to that by stadia readings are (1) that the angle, being a horizontal one, is less affected by the atmospheric disturbances known as boiling and differential refraction, (2) that longer distances can be measured, and (3) that by increasing the base length a high degree of accuracy can be obtained.

The method in use by some surveyors of measuring the distances subtended by a fixed angle (as, 34½′ or 1° 09′) is not to be recommended, because it offers no opportunity for precision and takes too much time to place the signals at the proper distance apart.

*Division Engineer, Los Angeles Aqueduct, Surrey, Calif.

Plane-table Surveys

When this method is used in connection with the plane-table, the alidade should be provided with a micrometer attachment to the eyepiece. The angle, which in this case is limited in size by the field of the telescope, is measured by the movement of a double hair attached to a sliding plate within the micrometer box. It is moved by means of a screw whose head is about ¾ in. in diameter and has its circumference divided into 100 spaces. Before the micrometer readings can be reduced to angular measure the value in seconds of arc of one division must be known; this can best be determined by a series of readings upon a measured base at a known distance from the instrument.

The precision to be attained in the measurement of the angle is defined by the scale of the map and the ratio of the size of the angle to the distance to be determined. On a scale of 1 in. = 1 mile the smallest distance that can be plotted on the plane-table sheet is about 0.01 mile, and, as the resulting error in the determined distance is proportional to the error in the measurement of the angle, we have $\frac{A}{100\,D}$ (in which A = angle in seconds, and D = distance in miles), as the allowable error in the measurement of the angle.

For example, a base of 256 ft. at right angles to the line of sight and at a distance of 10 miles subtends an angle of about 16′ 40″ or 1000″, and a precision of $\frac{A}{1000} = 1''$ in the measurement of the angle will be required to determine the distance within the limits of plotting. Under favorable conditions a single measurement should determine the angle within 5″, and a series of ten repetitions should give a mean value within 1″.

When possible, the base should be of sufficient length to insure a good determination of the distance by a single measurement of the angle.

The bases should be erected at prominent stations, commanding a good view of the country ahead, and nearly at right angles to the route of travel. For overland work one assistant only, to record and reduce the observations, is required. The position and elevation of a station is obtained by first orienting the table by means of a box compass and then observing upon the base station. The angle between the base and line of sight can be determined either with a prismatic compass or by measuring from the plane-table sheet with a small protractor. If not far from 90° no great accuracy is necessary.

The salient topographic features of the country are located by the usual method of intersections and the topography sketched in.

When traveling on water, a party of four men, two in each boat, will be required. The head rodman places the base signals, and alternate stations are occupied with the instrument. By this method a progress of 10 to 15 miles upstream and 20 to 30 miles per day downstream can be made.

This method has been used extensively by the U. S. Geological Survey on exploratory and reconnaissance work in Alaska.

On a survey by the writer in 1901 a continuous micrometer traverse was carried from Fort Yukon to Behring Sea, a total distance of about 1200 miles. The longitude of Fort Yukon as determined by Capt. Raymond of the Corps of Engineers, U. S. A., in 1866, was accepted as the starting point, and the longitude of Chamisso Island as determined by Capt. Beechy, in 1826, was accepted as the closing point. The total discrepancy in longitude due to accumulated errors in reading and plotting and shrinkage of the plane-table sheets was about 0.4 mile. At the summit of Chamisso Island was found a squared post set in a pile of rocks. The deeply carved lettering showed that the landmark had been set in 1826 by Capt. Beechy, who in that year was sent out by the English government to coöperate with Sir John Franklin and Parry in their search for the Northwest Passage. The inscription was "H. B. M. S. Blossom 1826." Another post was marked "H. B. M. S. Herald 1948" and "H. B. M. S. Plover 1849"; these last vessels carried two of the Sir John Franklin relief expeditions of those years. The latitude of the point as determined with a 4″ theodolite agreed exactly with that shown on Beechy's chart.

On another survey by the writer, in 1902, a micrometer traverse was carried from Tyonek on Cook Inlet (using the longitude of Tyonek as given on the best available maps) as the starting point, via the west base of the Alaskan Range to Rampart City on the Yukon, a distance of about 800 miles, where a connection for longitude with the previous survey from Fort Yukon was obtained by an azimuth line to a mountain peak about 50 miles nearly due north, which showed a discrepancy of 0.4 mile.

Engineering Work on the National Forests*

By M. R. Tillotson

In forest work, the fire danger is a real menace, and any plan of forest management is far from complete if it disregards detailed plans for the protection of the timber from fire. There are two chief rules for protecting timber lands from its greatest enemy: 1, Don't let a fire start; 2, if one does start, get a crew of men, equipped with tools and supplies, on the fire line without delay.

To appreciate the difficulties in following either of these rules one must remember that the national forests (with the exception of small areas in Florida, Minnesota, Kansas, Michigan and the Dakotas), include the great main divides of the Rockies, the Cascades and the Coast Ranges, and they cover therefore the roughest and most impassable country, steep divides, rocky cañons and unscalable peaks.

One of the most important features of the first rule is an effective patrol by fire guards and rangers, which means good mountain trails. When a patrolman discovers and locates a fire he must get into communication with the supervisor or with some district ranger who can organize a crew of fire fighters and rush them with their supplies and equipment to the scene of the fire without delay. The trails and roads must often cross deep ravines or swift mountain streams; which means bridges to build. The patrolmen and rangers, located at various points throughout the forest, must have permanent headquarters; which means cabins to build.

Engineering work on the national forests, as applied to fire prevention, is our greatest problem, and we consider our "permanent improvement" money spent to poor advantage unless every dollar of it goes to help decrease the fire danger. If two telephone lines are needed, the first one is built in the district where fires are most prevalent and dangerous. If a ten-mile road is thought necessary, it is not built if, by spending the same amount of money, we can build 25 miles of trail into a country which has no route of travel and where the fire danger is great.

On the Shasta national forest the total allotment for permanent improvements amounted to $5400 for the fiscal year ending June 30, 1912. Up to date we have, on this forest, constructed a total of some 90 miles of trail, 120 miles of telephone line, 3 bridges and 8 cabins, in addition to barns, nursery buildings and fencing.

The engineering or so called improvement work is directly in charge of the local force. The supervisor decides upon the improvement work to be done with the funds available. The telephone routes are then selected, trails and roads surveyed, bridge sites determined, etc., by the supervisor or deputy, and the project is placed in charge of a ranger with a crew of temporary laborers. Occasional inspections are, of course, necessary by the administrative officers of the forest, but the details of construction are left to the rangers in charge.

*From a paper in the "Purdue Engineering Review," Purdue University, Lafayette, Ind.

ROADS AND BRIDGES—It is very rarely the case that the rangers doing improvement work, or the administrative officers for that matter, have any technical knowledge of engineering. They are all good mountaineers, however; they know a good trail when they see it, and (what is more important) they know how to build one. Not one man in 500 who has ever built a Forest-Service bridge would know a modulus of rupture if he met it on the trail, but he does know how many stringers of peeled Douglas fir with a diameter of 12 in. at the small end, will be required to carry a safe bridge over a 28-ft. span.

The instrument most commonly used in laying out trail grades is an Abney hand level with an arc graduated to read in percents of elevation. To one accustomed to the use of a high-grade instrument in laying out road or railway grades, the degree of accuracy that an experienced man can obtain with one of these hand levels is surprising. A railway man could hardly comprehend a 20% grade. That, however, is the maximum trail grade used. It occasionally happens that it is necessary to make the grade a little heavier for a short distance, especially in making switch-backs up a steep ridge between two control points, such as a cabin in the bottom of a cañon and a pass on the summit above. Some of the old trails, especially the Indian trails, seem to have been built on the theory that a straight line is the shortest distance between two points and with no regard for grade. As fast as the money is available these old routes are being changed or abandoned entirely for better and well graded trails. Whenever possible, trail routes are selected along a water-course, on a water-grade, or along the top of a ridge. In many instances trails are surveyed on a wagon-road grade, so that later the Service, either alone or in coöperation with the state, county or private individuals can widen the original trail into a mountain road.

To put a trail into some places in the mountains would tax the skill of an experienced engineer. The level is not used until the entire route has been gone over several times and the most practical general route selected by eye and the knowledge of mountaineering, which is an essential qualification of even the youngest forest guard. After the grade stakes are set it is a matter of pick, shovel, mattock, brushhook, axe, steel drill, powder, time, hard labor and money to produce a highway through the forest.

TELEPHONE LINES—To build a telephone line, the services of an experienced man are required. On the Shasta we have a ranger who takes charge of all telephone construction and repair work. Although he is not a "telephone engineer," he has had enough practical experience to do any of the telephone work required. There is, however, in this district a special telephone man whose duty it is to visit the various forests, giving assistance and advice on the more technical points of telephone construction.

Except where a line connects with a supervisor's office in town, poles are rarely used, and the line is attached to trees, using split-tree insulators and 3½- to 4-in. wrought-iron staples. A tree line needs even more care in construction than does a pole line, since it invites a greater liability of future trouble. It is absolutely necessary that such a line have plenty of slack, since every tree in the line is likely to sway in the wrong direction at the same time; and without plenty of slack something is bound to break. Insulators are ordinarily located no higher than a bracket would be attached to a pole, thus lessening the amount of pull on the wire when the tree sways in the wind.

A "trouble shooter" on a telephone line through the mountains must frequently ride 15 or 20 miles to locate a break or ground, which may occur during the worst part of the fire season and when the line is most needed. Consequently it is usually economy to make the wire follow a trail, even if the cost of construction could be lessened by going across country where it might take several days riding through the brush and rocky mountain sides to detect and repair a breakdown. The entire length of the line must have 2½ to 4 ft. of clearance from branches and foliage, so that wind or branches loaded with snow will not cause a ground.

Our lines must necessarily be party lines, since many ranchers, if given free telephone connection with headquarters, will report fires that might burn for days before they would take the time and trouble to ride 8 or 10 miles and inform the nearest ranger. Too many connections, however, means too much load, and before granting private connections that might hinder a future extension of the line it is necessary to consider the matter from an electrical as well as from an administrative standpoint. The curiosity of the party liner is no less here than on a commercial line. When a party is listening in or leaves his receiver off the hook, it may be quite difficult for the other stations to ring each other or the set in question. Consequently our telephones are equipped with 2500-ohm condensers in order to obviate this difficulty.

Just as rapidly as possible all ranger stations and other important points throughout the forest are being connected with permanent telephone lines. During the summer, however, fire outlooks are stationed on the summits of some of the most prominent peaks, and during the past season we tried, with success, the system of connecting a lookout on Mt. Eddy (9000 ft.) with one of the trunk lines by means of five miles of No. 18 double-braid weatherproof copper wire laid along the ground and reeled up in the fall to be used again next season.

SURVEYING—In addition to construction work, every forest officer must have a good working knowledge of land surveying and the use of a surveyor's compass. There is scarcely a phase of national forest work where surveying is not necessary. One of the most important features of the examination for forest ranger consists of simple, practical questions on surveying and field work in handling a compass.

Practically all the work is done by compass, for which we have an admirable instrument made especially for the Service by the Gurley company. The aluminum base is 4 in. square, graduated on two sides in inches and tenths. The other two sides are so graduated that it makes a very serviceable protractor. It is equipped with a 2½-in. needle, clinometer, two leveling bubbles, 3½-in. folding brass standards and a movable dial with vernier for setting off the variation. A brass ball-and-socket joint is used to attach it to tripod or jacob staff, and the instrument is carried over the shoulder or on a belt by a leather case.

Very recently the Secretary of Agriculture and the Secretary of the Interior have entered into an agreement, whereby homestead claims within the national forests and on unsurveyed land may be patented, if chiefly agricultural in character, upon a metes and bounds survey by a designated forest officer. This requires a little higher knowledge of the subject, since the survey must be made with a transit according to General Land Office Standards and the bearing of at least one line must be determined by astronomical observation. This saves the settler the expense of hiring a deputy U. S. Surveyor, who formerly had to do the work.

MISCELLANEOUS—One of the most interesting branches of the engineering work of the Forest Service is that of a hydroelectric nature, done by the district engineers under the direction of the chief engineer, of San Francisco. This has to do with the regulation of the water-power industry and a wise use of the enormous power developed by the swift mountain streams of the forests, which are by no means the least valuable of our national resources.

Notes

The Strength of Crossarms has been tested by the Forest Service and it was found that for all ordinary pole-line conditions the crossarm is stronger than the pole. The arms tested were of Douglas fir, long-leaf pine (50% to 100% heart), short-leaf pine (plain and creosoted) and white cedar. The arms were about 3x4 in. in section (somewhat varying) and 6 ft. long, with three 1½-in. vertical pin-holes on either side of the center. The two inner pin-holes were each 8 in. from the middle. For the test the crossarm was gained and bolted to a short piece of pole and the outer end

of the attachment bolt was supported by an iron strap bracket. Vertical load was applied by the testing machine acting on a series of distributing levers, which brought equal load to bear on rods passing through the six pin-holes. The maximum load which the crossarm carried ranged from 4800 to 10,240 lb. (based on a standard section of 3.16x 4.10 in., the average size of Douglas fir arms). The crossarms of long-leaf pine were strongest, ranging from 9000 to 10,240. Douglas fir and short-leaf pine were slightly weaker. White cedar showed a strength of only about 5000 lb.; the failure in the case of white cedar was in nearly all cases a brash tension failure. In each case the corresponding lateral strength of the arm would be about 80% of the vertical strength, or about 4000 lb. for the white cedar crossarm. Since tests of poles have shown that their resistance to side pull is rarely as high as 3000 lb., and usually below 2000, it is seen that the crossarm is the stronger. The values above given are all averages of a considerable number of samples.

The compressive strength of the wood in these crossarms ranged from 4700 lb. per sq.in. for the white cedar to 9000 lb. for the better samples of long-leaf pine and about 7000 lb. for Douglas fir. Short-leaf pine ranged from 7300 for the plain arms to something below 6000 lb. per sq.in. for the creosoted arms.

It is concluded that for standard 6-ft. crossarms the question of strength need not enter into calculations of line construction except in rare cases of abrupt change in grade. The ability of the timber to resist decay, and methods of preventing decay, are much more important. (Forest Service Circular 204, Strength Tests of Crossarms, by T. R. C. Wilson).

A Triangle Formula to obtain the angles when the three sides are known, is given by Prof. C. Frank Allen (Mass. Inst. of Technology). While not new, it may be unknown to many of our readers, as the formula

$$\sin \tfrac{1}{2} A = \sqrt{\frac{(s-b)\,(s-c)}{bc}} \qquad (1)$$

is usually quoted without reference to the other method of solution. In the above, the sides are a, b and c, with the opposite angles A, B and C, and s is half the sum of the sides.

The derivation and formula given by Prof. Allen, are as follows: From angle C drop a perpendicular on side c, dividing c into the segments k and g, adjacent respectively to sides a and b. Calling the length of the perpendicular h, we have:

$$h^2 = b^2 - g^2 = b^2 - (c - k)^2$$

and

$$h^2 = a^2 - k^2$$

Then

$$a^2 - k^2 = b^2 - c^2 + 2ck - k^2$$

Whence

$$2ck = c^2 - (b^2 - a^2)$$

and

$$k = \tfrac{1}{2}\left[c - \frac{(b+a)\,(b-a)}{c}\right] \qquad (2)$$

Since $g = c - k$, we get

$$g = \tfrac{1}{2}\left[c + \frac{(b+a)\,(b-a)}{c}\right] \qquad (3)$$

When g and k are computed, the angles are readily found, as

$$\cos A = \frac{g}{b} \qquad \cos B = \frac{k}{a}$$

For many uses these formulas are more convenient than eq. (1), being probably less liable to errors of computation, and more quickly derived if forgotten.

A Beam and Plate Slide Rule has been prepared by the Des Moines Bridge & Iron Co. in unusually handy form. The rule consists of a cardboard slide moving in a celluloid sleeve about 3x8½ in. Slots cut in the two faces of the sleeve show graduations on the slide, registering with graduations along the sides of the slots. One side of the rule contains load scales for I-beams, channels, angles and tees used as beams; it gives both total uniform load and concentrated load. A subsidiary scale gives deflection, in inches. The other side of the rule gives the thickness of plate required for various depths of water in a standpipe or tank for different diameters of tanks and for different joint efficiencies. We understand that readers may obtain the rule gratis on application to the Des Moines Bridge & Iron Co., whose Pittsburgh office (Curry Bldg.) should be addressed.

Slope-Stake Setting is again under discussion after 12 years of comparative obscurity. For the benefit of those who still think that some undiscovered short-cut method of setting slope stakes may yet be discovered we print the following from a letter of O. H. Tripp, of Rockland, Maine:

In your issue for May 23 I notice two communications in regard to tables and diagrams for setting slope stakes. This subject seems bound to bob up about once in so often, but I must express my surprise at finding an engineer left who does not know of the "Ward tape." It surely seems strange to anyone of long experience (though for all I know both the writers may be veterans) to have anyone suggest carrying tables or diagrams in the field when the old reliable Ward can be had from any dealer for $3.25—only a trifle more than is paid for the common metallic tape—which saves all figuring beyond getting the cut or fill with the instrument.

This has been so often thrashed out that I hardly like to take up any space with it, but for the benefit of any young man who is not familiar with so simple a device I feel I must mention it. A full discussion may be found in Engineering News, Sept. 13, 1900, p. 182.

During the summer of 1900 a series of letters were published in Engineering News, which so completely cover the subject of setting slope stakes that we recommend their perusal to all interested parties.

Superelevation of Track—G. W. Snyder, Pennsylvania R.R. Co., Pittsburgh, calls our attention to the fact that the simple formula for superelevation of railway curves given by E. A. Hoffmann, in our issue of June 20, 1912, p. 1190, is found in Searles' "Field Engineering" (16th ed., 1895, p. 179). He also sends a blueprint instruction sheet which shows that this rule has been in use on the Pennsylvania for some years. The rule is that the correct superelevation for any curve is equal to the middle ordinate of a chord whose length in feet is 1.6 times the speed of trains in miles per hour. On the Pennsylvania the rule is modified by the following clauses:

No speed greater than 50 miles per hour should be assumed in determining the superelevation by the above method even though higher speed may be made.

No superelevation exceeding 7½ in. is permissible and none exceeding 6 in. should be used except at special locations on passenger tracks.

For particularly sharp curves a table of limiting superelevations is given, together with the speed which will be the ordinary limit on such curves. This table runs from 7 in. superelevation for 8° curves, 5 in. for 10° curves, 2 in. for 15° curves, down to 1½ in. for 20° curves.

Mr. Snyder further remarks as follows:

The rule as stated is correct only for standard gage (4 ft. 8½ in.). On the street railways in this vicinity, where gage is wider, the method would not give sufficiently accurate results, and on gages of 3 ft. or less it would really be dangerous.

To apply the rule on gages other than standard multiply the chord length calculated for standard gage by the square root of the ratio between the actual gage and the standard gage; e.g., for 36-in. gage, the chord length to be used is:

$$1.6 \times \sqrt{\frac{36}{56.5}} \times \text{speed}$$

Motor Truck Costs for Dirt Haulage in the removal of muck and tunnel rock from one of the Catskill Aqueduct shafts in New York City are given in an article by Geo. H. Hodges and J. M. Van Harlingen, of the International Motor Co., in a recent issue of the "Bulletin" of the General Contractors' Association. The Pittsburgh Contracting Co. is using 6½-ton motor trucks to remove this material from the aqueduct section lying between 176th St. and 99th St., to the dumping ground at 129th St. and the Hudson River. The distance from the farthest shaft to the dumping ground is about two miles.

The truck has a specially designed body on which a 4-yd. skip bucket can be rigidly attached. It is driven under the loading shoot at the mouth of the shaft and the material is dropped directly from the bins into the skip. The skips are removed from the trucks at the dumping ground by a derrick boom equipped with a dumping line. This line is hung from the end of the boom and is attached to a hook riveted at the rear of the bucket. The load is carried out over the dump by means of a hoisting line attached to the bucket and when the dumping point is reached the hoisting line is slackened and the load taken on the dumping line which tilts the bucket forward and discharges the load. Each truck makes an average of 12 trips per day, carrying a daily total of 42 cu.yd.

In estimating the costs, it is considered that 300 working days in the year is the maximum that a truck may be expected to operate, allowing for overhauling and holidays. The investment for the truck and its special platform body amounted to $6300. The cost, including interest on the investment at 6%, insurance, operating charges and garage, amounts to $3690 per annum, which is approximately 29c. per cu.yd. of material. It is claimed that with horse teams the cost was 80c. per yd.

In the above estimate the interest is figured on the full investment and no depreciation is charged against the truck. Estimating the cost of handling this material by motor truck when the interest is figured on half the investment and the depreciation is based on the mileage life of the truck, the cost was found to be 32c. per cu.yd. On this basis the truck earns 47c. per cu.yd., or a net profit of $19.47 per day over the horse-drawn equipment.

By using a trailer in connection with the truck a much greater reduction of cost could be made. The total load for each trip would then be approximately 13 tons. The additional investment and the maintenance of the trailer would be more than offset by the increased capacity, and according to the authors the cost of haulage would be reduced to approximately 17c.

It is claimed that in long hauls, 7 to 20 miles or more, a 6½-ton motor truck will replace 10 or 12 two-horse teams. In shorter hauls (two to five miles), one motor truck takes the place of from three to six two-horse teams or of two three-horse teams. This applies, however, only where the trucks can be kept continually in motion, with no considerable delays in loading.

A Surveying Instrument known as the rapid traverser, which, although it has been in use in England for a number of years, appears to be little known in this country, is described in the July 13 issue of "The Engineering and Mining Journal." The use of the rapid traverser is a variation of the plane-table method of plotting in the field. Instead of actually reproducing the traverse on a sheet of drawing paper fastened to a rectangular table the directions of the traverse lines or courses are marked off on rings on a white coated zinc disk.

The disk is fastened by drawing-pins or removable rivets to a circular table, which is mounted on a tripod. The alidade is in all respects similar to that used with a plane-table.

In traversing the instrument is set with the alidade clamped in position across the center of the disk. At the second station, or say B and the alidade is pointed to the first station or backsight A. The direction of the initial line of the survey A B is then marked with a sharp pointed pencil on one of several concentric rings into which the disk is divided, the object of several concentric rings being that each may be used for a separate traverse without disturbing the disk. These two marks on diametrically opposite sides of the ring are each lettered B, or given some other identification mark. The distance A B and the length of all courses must be measured by chain or stadia as in other traverse work. Having marked the direction of A B the alidade is unclamped and pointed to the next point C and again clamped. The direction of B C on the disk ring is now established, and marked C C.

Three tripod stands are generally used so that it is not necessary to move the clamped instrument attached to the tripod. The table and alidade in its clamped position only are moved to the next point C, where a tripod has already been set up. After the instrument is carefully centered over the hub C, the alidade is sighted to B and the table clamped in position. The alidade is then unclamped and sighted to D and the process repeated. In closing the traverse the last two check marks on the ring should, of course, coincide with the first two B B.

The direction of the magnetic meridian is usually determined by means of a trough compass placed against the back of the alidade's fiducial edge and marking the disk appropriately. The lengths of lines, offsets, etc., are taken in the usual way and recorded in the field notebook.

When the fieldwork is completed the disk is removed and taken into the drafting room, where it is used in lieu of a protractor to reproduce on the plan the direction of the courses. The angles must be measured by a protractor and the bearings thus determined.

It can easily be seen how the process may be reversed to reproduce in the field lines marked out on the plan for any particular purpose. Thus, by laying out a railway curve on paper, drawing the radiating lines from the P. C. and marking their positions on the disk when it is centered over the P. C., the deflection angles for the curve may be easily laid off in the field by means of the alidade.

Useful Points on Weighing Scales are given in a paper read before the Engineers' Society of Pennsylvania and published in its "Journal" for June, 1912, by Dr. F. Reichmann, Superintendent of Weights and Measures, State of New York, as follows:

It has only been in the last decade that real engineering thought has been applied to the design of multiple lever scales, such, for example, as the track scales of the Pennsylvania R.R. (described in Engineering News, Mar. 23, 1911). Yet every engineer has to deal with weighing scales in some form, and it is surprising how few engineers are well informed on the essential points in the manufacture of commercial scales.

To illustrate, there recently came to my attention a case of an industrial concern which had a two-ton scale for weighing ordinary iron castings and wished to use it for more accurate work in weighing copper. The scale was graduated to 5 lb. and sensitive to 5 lb. For the copper a scale reading to quarter-pounds was required. The engineer of the firm thought it was sufficient to order a new beam graduated to ¼ lb., and it took considerable demonstration to convince him that the whole scale would have to be replaced, and all the new parts made in accordance with the required sensitiveness and accuracy.

Another illustration of an engineer's lack of knowledge of scales was brought to my attention some time ago on a public highway job where the specifications called for a certain weight of surface dressing to cover a certain number of square yards of road. The scale used was on insufficient foundations and very inaccurate, resulting in a loss of 8% in the amount of surface dressing paid for. It might be mentioned in passing that the measurement of the square yards was liberal, so that the amount which ostensibly complied with specifications was used to cover actually about 1¼ sq.yd., which would, of course, materially impair the wearing qualities of the road.

Where an engineer has to prepare specifications or is called upon to install a scale, the following pointers should be borne in mind:

(1) Your specification should state the capacity of the scale.

(2) It should state the minimum graduation on the beam or the minimum reading if it is a dial scale.

(3) It should definitely state the sensitiveness at full load.

(4) It should specify that all pivots should bear their entire length.

(5) It should specify that there should be no deflection in the levers at full length.

(6) It should specify a stable foundation.

These are essentially aside from the material and size of platform and method of erecting. No scale should be accepted until it has been tested to full capacity.

I have in mind three pages of specifications on scales which were embodied in a public contract, and, although the size of platform, kind of wood on the platform, the maximum tensile strength of the members to be used in the construction of the scale and the color of the paint to be used had been mentioned, there was absolutely no statement as to the capacity, the sensitiveness, the stability or the accuracy; in short, under the three pages of specifications it was not essential to have a weighing device which could weigh.

In conclusion, the engineer should always consider well, from the standpoint of specifications, the quantity of material delivered under his orders; and any design of an industrial plant should make provision for weighing and measuring devices for checking the commodities received. In specifying such devices the engineer should be careful to specify those that can perform within reasonable limits, expeditiously and economically, the work they are supposed to do.

Shifting a Dredge Overland—A bucket dredge was removed overland from one dredging site to another by the Stanthorpe Proprietary Dredging Co., at Emmaville, New South Wales, by means of its own main hauling winch. The distance the dredge was moved was about half a mile.

The buckets and tumblers were removed from the dredge for separate transport, but otherwise the barge was left intact. A track for the dredge was roughly prepared along the hillside. Trenches were then dug some 20 yd. ahead, and headers put in. Wire ropes, with a suitable arrangement of pulleys, were fastened to the gantry framing of the dredge, taken out and passed around and connected to the head logs, and thence back to the main hauling winch of the dredge. The barge itself was run on skids about 10x10-in. hardwood, placed approximately 2 ft. apart. When these were laid in position the pull was commenced, and all going well, the dredge began to move.

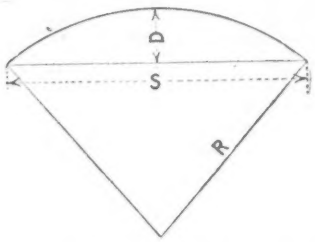
Great difficulties were encountered at first. The inclines from the dam to the road were very steep. Headers were not used at first, but trees and stumps were utilized instead, and in many cases were promptly uprooted. The haulage ropes used at first were much too light and constantly broke at the critical time. The weight of the dredge is 250 tons, and the pull on the ropes was 60 tons. Progress for some time was very slow, but toward the end of the journey an average advance of 60 ft. per day was maintained. Trouble was experienced throughout the job by the tendency of the skids to shift to one side directly the weight came on them. The ground in some places also caused great delay, owing to its softness and consequent inability to bear a load.

Operations were started about July 15, 1911, and the dredge successfully reached the site at the beginning of November.

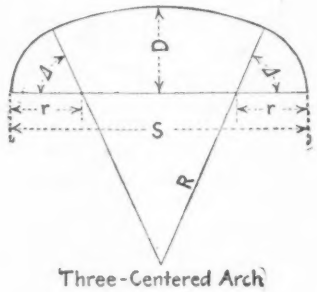
The cost of the work was about $4000. The best method of moving, if terms had been agreed upon with the land owners, would have been to work through the intervening ground. This could, at an outside estimate, have been done in a month, and, although a sluicing plant had previously treated the ground, a certain amount of tin would have been obtained from the dredge as it worked through. With regard to dismantling, it must have proved quicker than the present method, but the dredge is old, and some difficulty would have been experienced in putting it together again. It could, however, probably have been dismantled, removed, and rebuilt in three months.

The management claims that if the question of a further removal occurs again, the same method will be adopted, with the exception that many of the initial mistakes will be avoided. An improvement on the method would be to lay a line of rails and mount the dredge on small wheels, when progress would be greatly facilitated and much work saved in the moving of the heavy skids from length to length.—"Mining and Scientific Press."

FORMULAS FOR DIMENSIONS OF SEGMENTAL AND THREE-CENTERED ARCHES



Simple Arch



Three-Centered Arch

Given	Sought	Formula
Simple Arches		
S, D	R	$R = \frac{D^2 + (\frac{1}{2}S)^2}{2D}$
S, R	D	$D = R - \sqrt{(R + \frac{1}{2}S)(R - \frac{1}{2}S)}$
D, R	S	$S = 2\sqrt{D(2R - D)}$
Three Centered Arches		
S, D, r	R	$R = \frac{(\frac{1}{2}S)^2 - Sr + D^2}{2(D - r)}$
S, D, R	r	$r = \frac{2DR - D^2 - (\frac{1}{2}S)^2}{2R - S}$
S, R, r	D	$D = R - \sqrt{(R - r)^2 - (\frac{1}{2}S - r)^2}$
R, r, D	S	$S = 2\left(r + \sqrt{(R - r)^2 - (R - D)^2}\right)$
S, D, R, r	Δ	$\tan \Delta = \frac{R - D}{\frac{1}{2}S - r}$
$\Delta = 60°$: S, D	R, r	$R = \frac{1}{4}(3S - 2D) + \frac{1}{2}\sqrt{3(\frac{1}{2}S - D)^2}$ $R = 1.18301\,S - 1.36603\,D$ $r = S - R$
S, R	D, r	$r = S - R$ $D = R - \sqrt{3(R - \frac{1}{2}S)^2}$ $D = 0.86603\,S - 0.73205\,R$
S, r	D, R	$R = S - r$ $D = S - r - \sqrt{3(\frac{1}{2}S - r)^2}$ $D = 0.13397\,S + 0.73205\,r$
D, R	S, r	$r = R - 2\sqrt{\frac{1}{3}(R - D)^2}$ $r = 1.15470\,D - 0.15470\,R$ $S = R + r$
D, r	S, R	$R = 4D - 3r + 2\sqrt{3(D - r)^2}$ $R = 7.46410\,D - 6.46410\,r$ $S = R + r$
R, r	S, D	$S = R + r$ $D = R - \frac{1}{2}\sqrt{3(R - r)^2}$ $D = 0.13397\,R + 0.86603\,r$
$\Delta = 45°$: S, D	R, r	$R = \frac{1}{2}S + \sqrt{\frac{1}{2}(\frac{1}{2}S - D)^2}$ $R = 0.85355\,S - 0.70711\,D$ $r = \frac{1}{2}S + D - R$
S, R	D, r	$r = S - R - \sqrt{2(R - \frac{1}{2}S)^2}$ $r = 1.70711\,S - 2.41421\,R$ $D = R + r - \frac{1}{2}S$
S, r	D, R	$R = r + \sqrt{2(\frac{1}{2}S - r)^2}$ $R = 0.70711\,S - 0.41421\,r$ $D = R + r - \frac{1}{2}S$
D, R	S, r	$S = 2\left(2R - D - \sqrt{2(R - D)^2}\right)$ $S = 1.17157\,R + 0.82843\,D$ $r = \frac{1}{2}S + D - R$
D, r	S, R	$S = 2\left(D + \sqrt{2(D - r)^2}\right)$ $S = 4.82843\,D - 2.82843\,r$ $R = \frac{1}{2}S + D - r$
R, r	S, D	$S = 2r + \sqrt{2(R - r)^2}$ $S = 1.41421\,R + 0.58579\,r$ $D = R + r - \frac{1}{2}S$

Dimension Formulas for Arches

By Henry W. Aplington*

In the accompanying series of formulas the various parts are represented thus:

Span = S

Rise = D

Large radius (or radius of simple arch) = R

Small radius = r

Curvature angle of small radius = Δ

The formulas comprise: (1) those for the simple arch, which are in common use and are included only for completeness; (2) the general case of the three-centered arch, where Δ is not assumed, and any three of the remaining parts are known; (3) special formulas, assuming two common values of Δ, 60° and 45°, any two of the remaining parts being known. Both the algebraic and the numerical forms of the special formulas are given.

Timber Mill Floors—A table of safe loads and spans for timber mill floors for various unit-stresses is given below. It contains also the limiting span for a deflection of $^1/_{360}$ of the span. The load calculations were made for a total load consisting of the stated live-load and the weight of the planking. The deflection calculations are based on a modulus of elasticity of 1,685,000 lb. per sq.in. We reprint this table from a circular issued by the Yellow Pine Manufacturers Association (Wright Bldg., St. Louis, Mo.) The load figures are, with inconsiderable error, applicable to white pine, hemlock or other timber provided the proper unit-stress is used. Thus to design a floor of hemlock for a unit-stress of 750 lb. per sq.in., the table would be entered at 1500 lb. and twice the live-load which it is desired to use.

*Bridge Dept., N. Y. C. & H. R. R.R., New York City.

LOADS AND SPANS FOR FLOOR PLANKING

Thickness in inches	Stress per Square Inch, Pounds	SPAN IN FEET AND INCHES — Live Load in Pounds Per Square Foot: 100	125	150	175	200	225	250	275	300
$1\frac{5}{8}$	1200	6′ 4″	5′ 8″	5′ 3″	4′ 10″	4′ 6″	4′ 4″	4′ 1″	3′ 11″	3′ 9″
	1300	6′ 7″	5′ 11″	5′ 5″	5′ 0″	4′ 9″	4′ 6″	4′ 3″	4′ 1″	3′ 10″
	1500	7′ 1″	6′ 4″	5′ 10″	5′ 5″	5′ 1″	4′ 10″	4′ 7″	4′ 4″	4′ 2″
	1600	7′ 4″	6′ 7″	6′ 0″	5′ 7″	5′ 3″	5′ 0″	4′ 8″	4′ 6″	4′ 4″
	1800	7′ 9″	7′ 0″	6′ 5″	5′ 11″	5′ 7″	5′ 3″	5′ 0″	4′ 9″	4′ 7″
	Deflection	4′ 8″	4′ 4″	4′ 1″	3′ 11″	3′ 9″	3′ 7″	3′ 5½″	3′ 4½″	3′ 3″
$2\frac{5}{8}$	1200	10′ 1″	9′ 1″	8′ 4″	7′ 9″	7′ 3″	6′ 11″	6′ 6″	6′ 3″	6′ 0″
	1300	10′ 6″	9′ 6″	8′ 8″	8′ 1″	7′ 7″	7′ 2″	6′ 10″	6′ 6″	6′ 3″
	1500	11′ 3″	10′ 2″	9′ 4″	8′ 8″	8′ 2″	7′ 8″	7′ 4″	7′ 0″	6′ 8″
	1600	11′ 8″	10′ 6″	9′ 8″	8′ 11″	8′ 5″	7′ 11″	7′ 7″	7′ 2″	6′ 11″
	1800	12′ 2″	11′ 2″	10′ 3″	9′ 6″	8′ 11″	8′ 5″	8′ 0″	7′ 8″	7′ 4″
	Deflection	7′ 5½″	6′ 11½″	6′ 7″	6′ 3″	6′ 0″	5′ 9½″	5′ 7″	5′ 5″	5′ 3″
$3\frac{5}{8}$	1200	.....	.....	11′ 3″	10′ 7″	10′ 0″	9′ 5″	9′ 0″	8′ 7″	8′ 3″
	1300	.....	.....	11′ 8″	11′ 0″	10′ 5″	9′ 10″	9′ 4″	8′ 11″	8′ 7″
	1500	.....	.....	12′ 7″	11′ 10″	11′ 2″	10′ 7″	10′ 0″	9′ 7″	9′ 2″
	1600	.....	.....	13′ 0″	12′ 3″	11′ 6″	10′ 11″	10′ 4″	9′ 11″	9′ 6″
	1800	.....	.....	13′ 9″	13′ 0″	12′ 3″	11′ 7″	11′ 0″	10′ 6″	10′ 1″
	Deflection	10′ 2½″	9′ 6½″	9′ 0″	8′ 7″	8′ 3″	7′ 11½″	7′ 8″	7′ 5¼″	7′ 3″
$4\frac{5}{8}$	1200	.....	.....	.....	.....	12′ 7″	11′ 11″	11′ 4″	10′ 10″	10′ 5″
	1300	.....	.....	.....	.....	13′ 2″	12′ 5″	11′ 10″	11′ 4″	10′ 10″
	1500	.....	.....	.....	.....	14′ 1″	13′ 4″	12′ 9″	12′ 2″	11′ 8″
	1600	.....	.....	.....	.....	14′ 7″	13′ 9″	13′ 2″	12′ 7″	12′ 1″
	1800	.....	.....	.....	.....	15′ 5″	14′ 8″	14′ 2″	13′ 4″	12′ 9″
	Deflection	12′ 11″	12′ 1″	11′ 5½″	10′ 11″	10′ 6″	10′ 1″	9′ 9″	9′ 6″	9′ 2½″
$5\frac{5}{8}$	1200	.....	.....	.....	.....	15′ 3″	14′ 5″	13′ 9″	13′ 2″	12′ 7″
	1300	.....	.....	.....	.....	15′ 10″	15′ 0″	14′ 4″	13′ 8″	13′ 1″
	1500	.....	.....	.....	.....	17′ 1″	16′ 1″	15′ 4″	14′ 8″	14′ 1″
	1600	.....	.....	.....	.....	17′ 7″	16′ 8″	15′ 10″	15′ 2″	14′ 7″
	1800	.....	.....	.....	.....	18′ 8″	17′ 8″	16′ 10″	16′ 1″	15′ 5″
	Deflection	13′ 7″	12′ 8½″	12′ 0½″	11′ 6″	11′ 0½″	10′ 8″	10′ 4″	10′ 0″	9′ 9″

Note—The table can be used for lower unit-stresses than 1200 by entering with a multiple of the selected unit-stress and the same multiple of the live-load. For hemlock, 1000 lb. fiber stress, 200 lb. load, enter table with 1500 and 300 to get safe span.

Letters to the Editor

The Peaked Crown for Street Pavements

Sir—It was with much surprise that I read in your issue of July 18, 1912, p. 120, the communication of Horace Andrews stating that he had, as early as 1897, published a design for street crowns practically identical with that printed in my article in your issue of June 6, 1912, p. 1086.

I do not remember ever to have seen a copy of Gillespie's "Roads and Railroads" as revised by Staley, though I think I have in my library copies of three earlier editions of the work. I confess to complete ignorance of Mr. Andrews' work in this particular matter.

I was not ignorant of the fact that many modified street contours intended to remedy the obvious defects of the circular cross-section have been proposed, advocated and used for a long time, but all of these were either empiric, or involved compound curves, i.e., curves whose radii increased from the center of the street to the curb. My idea was to adopt the "peaked" form of crown with comparatively flat circular curves of constant radius, and to reduce it to a workable, standard system.

Whatever apologies for my ignorance are due to Mr. Andrews, yourself and your readers are humbly offered.

S. WHINERY.

95 Liberty St., New York City,
July 20, 1912.

Formulas for Velocity Head on Railway Grades

SIR—In E. H. McHenry's valuable book, "Rules for Railway Location and Construction," there is a discussion of virtual grades in which a formula for velocity heads and a table based on the formula are given. Both the formula and the table are taken from A. M. Wellington's monumental work, "The Economic Theory of Railway Location," and give the velocity in miles per hour and the velocity heads in feet. The formula and the table both seem to be in error. The usual formula for velocity heads is $h = v^2 \div 2\,g$, in which h equals the velocity head in feet, v equals the velocity in feet per second, and g equals the acceleration due to gravity. Taking g equal to 32.2 and letting v equal the velocity in miles per hour, the coefficient of v^2 reduces to 0.0334 instead of 0.0355, as given by Wellington.

W. A. WARREN.

North Yakima, Wash., July 1, 1912.

[If our correspondent will look up Wellington's "Economic Theory of Railway Location" (p. 336), he will find his own formula and result are given ($0.33445\ v^2$), but that this is followed by an allowance of 6.14% for the energy stored in the revolving car-wheels, giving as the final figure, $0.0355\ v^2$. After this explanation it is unecessary to give the tables accompanying the above letter.—EDITOR.]

Some Peculiar Bidding on Highway Bridges

Sir—In connection with your editorial in ENGINEERING NEWS, June 13, 1912, p. 1137, entitled "State Control of Highway Bridge Construction," the following account of a bridge letting in this county may be of interest.

In June of this year, the county supervisors opened the following bids on three steel highway bridges:

	Bridge I.	Bridge II.	Bridge III.
A. Co.....	$3500	$3031	$3126
B. Co.....	1960	3980	4004
C. Co.....	3000	4000	4096
D. Co.....	1550	2695	2695

As soon as the bids were announced, vague charges of pooling were brought against companies A, B and C, with the result that the bridges were readvertised, the new bids being opened the early part of this month.

C company did not bid in this new letting, but the other three bids were as follows:

	Bridge I.	Bridge II.	Bridge III.
A. Co.....	$1244	$1631	$1631
B. Co.....	1545	1666	1810
D. Co.....	1721	1745	1745

As a result, the contract for the three bridges was let to A company at a total price of $4506, as against the $9657 bid in the first letting. The county saved some $2500, the difference between the low bids in the two lettings, but the question remains as to where the $5000 extra bid by A company in the first letting was intended to be applied.

X. Y.

Vicksburg, Miss., July 12, 1912.

More Concerning Engineers' Salaries

Sir—The following significant sentence appears in ENGINEERING NEWS of July 4, in the article by Prof. Marburg, on "Engineering Graduates and the World," p. 30:

> It may be of interest to add, that of the total number of graduates, 1258, beginning with the class of 1873, more than one-half have graduated since 1904.

Prof. Marburg was writing about the University of Pennsylvania, and it would be very interesting to know if this enormous recent increase in attendance is true of a majority of the technical schools in the United States.

It is 25 years since I left school and "got a job" as a draftsman. The ordinary pay for young draftsmen at that time was $50 per month. A good draftsman was considered worth only $75 and a draftsman who received as much as $100 per month was thought to have some sort of "pull." Transitmen received $90 per month and found, levelers $75 per month and found, and field draftsmen received from $50 to $75 per month and found. Today the pay of men in the field is no higher, but it is a mighty poor draftsman one can get for $75 these days. A draftsman who works for $90 per month in a city office is not a very good man as a rule, and if he is a good man he simply takes the pay until he can get a better paying job. The office man is certainly getting better pay now than in the old days, while the pay of the man in the field is not improved. In fact, the pay for outside men is slowly lowering.

Twenty-five years ago it was a very poor man who would run an instrument and inspect sewer and water-works construction for less than $125 per month, the greater number getting from $150 to $200 per month. In those days it was hard to find a man under the age of 30 doing such work, whereas today $100 is good pay and in a great many places men are doing the work for from $60 to $80 per month, often furnishing their own instruments. It is noticeable also that men more than 30 years old are seldom found in this work, most of the assistants to whom the work is intrusted being out of school less than five years.

Traditions die hard. Twenty-five years ago the man outside had more steady employment and larger pay than the man inside and this being handed down as a tradition leads young men to seek the outside work rather than the inside work. The best place now for young graduates to start is as near headquarters as possible. Here they have a better chance to become acquainted with the details of the business and to know the head men. Work is continually coming in and there is a prospect for steady employment and for promotion, because so many dissatisfied men drop by the wayside. The field man, on the other hand, is employed only at certain seasons of the year and his wages are charged to the

expense column on the books. He has small opportunity to become known to many of the head men and when he gets past the age of 30 he is up against it good and hard to secure any employment.

Twenty-five years ago a young man educated as an engineer was not regarded very highly, while today everyone wants him, because the number is so great that graduates can be had very cheaply indeed. The reason for a large number of failures is that the boys do not know that within the past eight years, at one large school at least, more men have graduated as engineers than in the thirty-one years from 1873 to 1904. If they could realize that fact, together with the fact that in the 70's engineers were really more in demand, in proportion to the population, than they are at present, they might be content to start in at lower pay and take their chances alongside other young men of their age who have not had such excellent technical training.

The day has forever gone by when a young man with a technical training is going to start at better pay than the young man without it. His technical training today merely gives him a better chance to get a job. Nothing more. There was a time, several generations ago, when eminent engineers received enormous fees, for that day, for consultation services, and their assistants received nothing, being apprentices. Then the pay of the head men kept going down, and the assistants first got low compensation, and finally reached the point where they got nearly as much as their superiors. That was at the time when I graduated.

For the past 20 years conditions have gradually been working around to where the big engineers are again receiving high pay because of their reputations and their assistants' pay is again going down. There are so many ordinary men, you know. When there were few engineers and much work, it was easy to get high pay, this being, of course, a relative term; but as engineers increased in numbers and there was just about enough work to keep them busy, the pay had to reach practically an average rate. At the present time there is a great deal of work and many engineers with large organizations, so the few who can raise their heads above the general level and attract attention in the crowd can command high pay, while the enormous number in the rank and file must be content to receive what they can get.

The average graduate should be content to secure a position where he can be sure of fair pay and steady employment, with a prospect of promotion. That is, the graduate of a technical school today is in exactly the position of the graduate from other college courses, except that as a rule employers prefer technical graduates to "arts" graduates, with their useless stock of deceased language and literature. I studied Latin and Greek myself.

The draftsman who today receives $125 per month is of a grade equal to the man who 25 years ago received $75 per month. The man today, however, turns out easily three times as much work in one day. If he does not he will be discharged. In those days men were draftsmen and I like to look over some of the work I did then and occasionally wonder if I really did do it. We were never hurried. Nice white paper! Complete drawings, always inked in! Oftentimes tinted! Nice, leisurely times, those were. Now I get after my draftsmen and push them with soft-pencil work on thin paper, sometimes with black carbon paper reversed against the under side, the blueprints being made directly from the paper tracing with its soft-pencil lines. In my early days we fired a man who used a soft pencil, or who used bottled ink, or who traced on the rough side of the tracing cloth. Queer little kinky ideas in those pleasant days!

While we bemoan the days when "drafting was an art," the fact remains that not one draftsman in fifty today would have the patience to do the work we did then. He is infected with the spirit of the times and likes the thin paper, the soft pencil, the electric blueprint, done and returned to the office in 15 minutes. What would he have done in the olden days when we sometimes were tied up for blueprints for a week when the weather was gloomy and when the man who worked fast was "called down" by the rest of the fellows in the office, who were afraid to work fast for fear of a lay-off before another job came into the office.

I had charge of a building 19 years ago which took 18 months to erect. Five years ago I had charge of a building of practically the same dimensions and in which there were many similar details, which I turned over to the owners in six months after work was started and was humiliated at not completing it sooner, but a railway strike held up shipments and delayed us a month. This year we had a similar building turned over to the owners in five weeks under six months.

In the old days pay was lower, work was slower, living costs were not high, although I remember people were always talking about the high cost of living. From 1873 to 1904 one of our leading technical schools turned out a little over 600 graduates, and in the eight years since then has turned out more than it did in the preceding 31 years. There are more schools, too, and the instruction is broader. The pay of the man near headquarters is slowly going up, and the pay of the man outdoors is slowly going down. The American Society of Civil Engineers decided at the recent annual convention that it is not advisable for the Society to help engineers secure positions; but for statistical purposes it will report, when the committee is through, on conditions of employment and compensation for engineers!

In my own case I find that men over 40 are not wanted. People can talk themselves black in the face arguing with me, but I simply say, "Wait until you pass 40 and if you are unlucky enough to have been one of those fellows who never landed a permanent job, you will agree with me that there is a dead line drawn about the age of 40 for all men who have to work on salaries." The young men should know this and their teachers should tell them. Two young men, not yet graduated, refused to go to work on parties for me this summer because having completed their studies in surveying, they thought they should take a level or transit at least. Their teachers told them the world judged all men by the value they set upon themselves! What rot!

I received $250 per month a few years ago for certain work and a few weeks ago answered a blind advertisement for a similar position and asked only $60 per week. The letter was answered by a man I knew, who told me that he had received applications from 200 men and that 164 were willing to work for less than $40 per week, and more than half of them for $25 to $30 per week. Out of the entire lot of 200, only 50 were more than 30 years old. All the older men wanted pretty good pay. He then went on to say that he had made a special plea for me and was told to employ me if I would work for $50 per week, and was going to write me when his employer suddenly noticed my age, 45, and said he would not have a man over 30, because "young fellows work faster and take orders better."

Reminiscences are generally valuable reading because they consist of experience, and lack of experience spoils many men's chances for advancement. I personally want to see all young fellows succeed, although not such an ancient of days myself and in splendid health.

A. N.

Chicago, Ill., July 5, 1912.

Notes and Queries

In the discussion on centrifugal pumps for water-works service, printed on page 70 of our issue of July 11, a line was accidentally omitted which gave credit for the opening remarks of the discussion to Mr. J. N. Chester, of Pittsburgh, Penn.

In the article "Effect of Storms on a Lake Breakwater," by L. W. Goddard, in our issue of July 18, 1912, p. 91, line 2 in the second column of p. 91 should have been placed at the end of that column, and line 6 in the second column of p. 92 should have been placed at the top of that column. In the second column of p. 92, last line, "Figs. 9 to 14" should have been "Fig. 1."

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Engineering News

The Teaching of Physics in Engineering Schools

Elsewhere in this issue, Prof. Daniel F. Comstock, of the Massachusetts Institute of Technology, urges the establishment of special courses in what he calls "industrial physics" in the engineering schools. He says that at the present time the teaching of physics is designed either for elementary training or, in the case of advanced courses, it is devoted to problems in so called pure physics, designed to train the scientist or the teacher. He urges that physics should be taught in a way that will prepare the student for work in laboratories devoted to physical investigations in connection with the the industries.

It is probably true that the average engineering graduate, or even the exceptional one for that matter, is lacking in a thorough grasp of physical facts. The remedy we should prefer, however, would be to reform the teaching of physics generally in the engineering schools rather than to establish special courses in so called "industrial physics." We regard with grave doubt special courses of any sort in undergraduate work. A student to be properly trained for work in the physical-investigation department of a manufacturing concern would need to be thoroughly grounded not only in industrial physics, but in industrial chemistry, in all the practical details of the machine shop and the foundry, in theoretical mechanics, to a certain extent in botany and mineralogy, nor can he neglect the other studies forming part of the regular course if he aims to be the kind of all-round man who alone is fit to solve the tough problems which are put up to such departments of a manufacturing concern. We sincerely hope, therefore, that Prof. Comstock's interesting little contribution will be taken as an argument for better methods of teaching physics rather than a defense of the policy of further specialization in our engineering schools.

A Mutual Defense Fund in an English Engineering Society

It needs no argument to prove that an attack upon the professional reputation of an engineer of prominence not only works an injury to him but hurts the reputation of the profession as a whole. An English society of engineers deserves credit for taking the initial step to recognize this fact by providing means whereby the society itself may aid in protecting the reputation of an engineer unjustly accused. The movement in question in the English society, the Institution of Municipal and County Engineers, grew out of an attack made upon one of its prominent members, William Jones, engineer of Colwyn Bay, Wales. A local newspaper brought charges against Mr. Jones, and in order to defend his reputation he was obliged to bring a suit for libel against the proprietor of the newspaper. The jury not only exonerated Mr. Jones from the charges but gave him a verdict for heavy damages against the newspaper proprietor. The man, however, proved to be financially irresponsible and Mr. Jones was not only unable to collect the damages but was saddled with the expense of the litigation as well.

The Council of the Institution recognized that Mr. Jones was defending the reputation of the profession as well as his own in conducting this suit. They, therefore, propose to establish a mutual defense fund which can be drawn upon by vote of the Council to aid members in circumstances such as these. While such a fund would have to be properly safeguarded to prevent its use in aid of unworthy members, there can hardly be a question that the profession as a whole owes it as a duty to aid those of its members who through no fault of their own are brought into difficulties concerning their professional work in a manner which affects the prestige of engineers generally.

Shipping Cement In Bulk

As some of our readers will recall, ENGINEERING NEWS has several times strongly urged the advantage of shipping cement in bulk in tight box cars from the mills to large contract operations, thereby saving the cost of packing in bags or barrels, the cost of the packages and the perennial nuisance and expense in connection with the return of bags.

It is of much interest, therefore, to note that the Universal Portland Cement Co. has begun making shipments of cement in bulk. According to an official statement made by the company, when the car was unloaded with shovels and wheelbarrows, there was no more dust than is experienced in unloading cement in sacks. To gain the full advantage from the shipment of cement in bulk, however, it will be necessary to develop automatic unloading appliances by which some sort of portable conveyor can be shoved inside a car and the cement be carried in a closed tube or trunk to the

point of delivery. There would seem to be nothing impracticable in the design of some such conveyor operating either with an endless screw or with an endless belt and attached buckets.

As the present low prices of cement seem likely to rule indefinitely, the cost of the packages is a large percentage of the cost of the cement. This is true even with the commonly used cement bags on account of the great wear and tear and the percentage of loss as well as the cost of keeping account of bags sent out and returned.

Of course, one of the objections which will be brought against the shipment of cement in bulk is its liability to injury by exposure to the weather. According to the latest investigations with respect to cement, however, the added aëration which cement will receive by handling in bulk in loading and unloading will be a distinct advantage to the material. Even if there should be a little loss on a carload in handling and unloading or from occasional small roof leaks, the loss of a barrel or two of cement from a carload by such causes would be so trifling a matter, compared with the saving that might be made by eliminating all packages, that it would constitute no real objection to the system of shipping in bulk.

Selling Land in the Florida Everglades

We have received a copy of *The Everglade Magazine*, published by the Everglade Land Sales Co., Majestic Bldg., Chicago, C. W. Helm, general sales agent. Mr. Helm is also the editor of this publication, which is issued monthly, "to report the progress of America's latest empire—the Florida Everglades."

The leading article in this magazine is by J. O. Wright, Chief Drainage Engineer, Tallahasse, Fla.

The reading matter in the publication is notable for the contrast between the large-type headlines, aimed to promote land sales, while certain qualifying remarks are printed in ordinary type where the careless reader will not notice them.

Some of the headlines read as follows: "Company's improvements going forward at a rapid pace," "Dredges made great headway during month," "Congress petitioned to assist drainage," "Sugar cane the most promising staple for the Everglades," "Natural sources of fertility in Florida's great drainage project."

Some of the qualifying remarks read as follows: "It was not expected that any immediate benefit would accrue from the drainage until the main canals were completed and the lake lowered." "Under no circumstances should any purchaser make any arrangements to migrate to the glades until we have advised him that his land is ready for occupancy." "Owing to the excessive rain of the recent past, all the lowland throughout the country is flooded."

The advertisement of the Land Sales Co. offers land in the Everglades at prices ranging from $50 per acre (sold on installments at $1 per acre per month), to $80 per acre, or $2 per acre per month. These enormous prices for unreclaimed swamp lands in Florida should be sufficient to put a wise man on his guard; but the people who buy far distant lands on the instalment plan are not always wise.

It is a thousand pities that the State of Florida should lend its support to a huge land speculation and the sale of land on installments to poor purchasers who cannot afford to run risk of loss. For the state's whole drainage enterprise rests on an insecure foundation. Will the work now in progress on the canals from Lake Okechobee have sufficient effect in draining the Everglade region or any considerable part thereof so that the land can be lived upon and profitably cultivated? The sworn testimony of engineers of high standing in a recent investigation at Washington has proved conclusively that the State of Florida is proceeding blindly in this important matter. It has undertaken an engineering project involving the expenditure of several hundred thousand dollars with no adequate engineering information as to whether the work will produce any results in the way of benefits at all commensurate with its cost. It is bad enough to spend the money of taxpayers on any such speculative basis, but it is ten times worse to allow the reputation and credit of the state to be made use of by land speculators to further the sale of lands on installments at absurdedly high prices to people of small means scattered all over the country.

We feel it important to speak emphatically on this matter, for it is easy to foresee that a few years hence, when the bubble bursts and it is found that the construction work which has been done does not give the expected results, it will be attempted to lay the blame on the engineering profession. It will be then said that the engineering plans were at fault, and that the state authorities and the people who are selling these lands were themselves deceived.

For the credit and good name of the engineering profession, therefore, we feel it important to make this protest now and to publicly spread the warning that the State of Florida is proceeding with its Everglade drainage scheme with no adequate engineering investigation to determine what work should be done, how it should be done and what the cost will be. We repeat what we said in our issue of Mar. 28: The State of Florida should submit its present plans for draining the Everglades to a Commission of competent engineers before proceeding further.

The Lessons of Two Recent Collisions Under the Block System

The three horrible railway collisions which occurred during the first fortnight in July have called renewed public attention to the need of better means for securing the safety of railway travel.

Concerning the wreck on the Ligonier Valley R.R., where a passenger car being pushed by a locomotive at high speed collided with a double-header freight train, little need be said further than it illustrates only too forcibly the crude and dangerous methods of railway operation which are too common on many of the small local railways and branches scattered all over the country. We have already alluded to the reprehensible practice of running a passenger car ahead of a locomotive. The official investigation showed that the movement of trains on this road was most unsystematic. Train orders were issued verbally, no written record being made, and in fact the circumstances all contributed to make possible the disaster which finally occurred.

Chief interest centers, however, in the two fatal collisions under the block system, one on the Lackawanna R.R. at Corning, N. Y., and the other on the Chicago, Burlington & Quincy R.R. at Western Springs station, 15 miles west of Chicago. In the Lackawanna accident, there seems no ground whatever to criticize the signaling practice. Not only was the standing train protected by a home signal at danger and a distant signal 4000 ft. in the rear standing at caution, but the additional protection required by the flagging rules was rigidly carried out, the flagman going back 2000 ft. and burning a fusee to warn the approaching train. The entire responsibility for the accident, therefore, lies with the engineer of the express train, Schroeder, who ran past these three successive warnings.

According to the reports which have reached us as to the testimony of this engineer under examination at the coroner's inquest, his claim is that he found one of the injectors out of order and had difficulty in starting the other injector, as its rod came against the side of the cab, which had become loose on the engine frame. It was while he, with the aid of the fireman, was trying to bend the rod on this injector so that he could operate it that he passed the flagman with his burning fusee without seeing him.

This explanation wholly fails to account for his disobedience to the block signals. Schroeder had been running over this section of the road for 23 years; he knew every inch of it. No emergency of whatever sort in the operation of a locomotive justifies an engi-

neer in passing a block signal without identifying it. If from any cause whatever he does pass such a signal without being certain as to its indication, it is his business to immediately apply the brakes and check the speed so that he can certainly stop his train before he reaches the signal ahead.

If it be assumed that Schroeder is telling the truth as to his being busy with the injector at the fatal moment when he should have seen the warning of the flagman, it is an excellent demonstration of the inherent danger of the flagging system. It is impossible to secure from any engine driver, no matter how experienced or infallible, vigilant attention to the track ahead at every instant of his run. There will be moments when his attention should be and must be diverted in other directions, but under the block system he has an opportunity to attend to these things between the passage of signals.

Turning now to the Western Springs collision on the Chicago, Burlington & Quincy, we give in another column the best account available as to the circumstances of that disaster, prepared by a member of the editorial staff of this journal who visited the scene of the disaster and obtained information from the railway officials.

The first thing that arrests attention in connection with this accident is that it is not a case of an isolated engineer rushing with his locomotive headlong to destruction, despite the warning of danger signals, as happened at Corning, for at Western Springs three trains in succession ran past the block signal standing at danger.

It should be explained that the signal at Western Springs was placed at danger by the operator because near the block station two miles ahead a freight train was pulling off from the eastbound track onto the middle track, also used at this time for eastbound traffic. Apparently the rules under which the road is operated contemplate the frequent running of trains past danger signals, for they provide that when this occurs the train shall not back up, but shall send the rear flagman to the tower which has been passed to report and obtain permission for the train to proceed as soon as the block is clear.

Apparently the first train which ran past the danger signal at Western Springs on that fatal morning did not obey this rule. It is not at all improbable that when the engineer found that he had run past a danger signal he thought it safer for himself and his train to slacken speed and run slowly to the next block station. By the time he reached there the freight train was probably out of the way and the block was cleared. He went ahead and appears not even to have been reprimanded.

The engineer of the second train, a through passenger train from Denver, obeyed the rule, however, and brought his train to a stop when he had run about 850 ft. past the home signal. The signal operator in the tower at Western Springs was a woman. She saw the first train run past her danger signal and not long after received word of its passage by the next signal tower to the east. Meanwhile the second passenger train had also run past her danger signal and she seems to have reasoned that inasmuch as the first train disobeyed the rule and ran ahead without stopping, the second train also would do the same. In ordinary weather she could see the train nearly all the way to the next signal tower, and it is quite likely that she was accustomed to give the "line clear" signal to the tower next to the west as soon as a train had passed her tower and gotten out of sight. Indeed it is possible that there was no provision whatever for overlap in the operation of this block system and that operators were permitted to give a clear signal to the tower back of them as soon as a train had passed their own signal.

At any rate, not long after the passenger train had passed the Western Springs tower and gone out of sight in the fog, the operator there flashed back a clear signal to the tower at West Hinsdale, 2½ miles to the west. In accordance with this information, the operator at West Hinsdale gave a clear signal to train No. 8, composed of through mail cars. This train also dashed past the home signal at Western Springs standing at danger as had the two preceding. Like the two preceding engineers, the man at the throttle of this train seems to have seen the danger signal when he was close upon it and to have attempted to stop the train, but a distance of 800 to 1000 ft. is inadequate to stop a passenger train running at 60 miles an hour, as is stated to have been its speed. The locomotive crashed into the rear of the standing train, demolishing the rear sleeper. That the speed was materially checked before the collision seems certain, else the cars ahead of the rear car would have experienced more damage. The engine runner himself was killed in the wreck.

In the report furnished us, the official investigation of the railway company places the primary blame upon the rear flagman of the standing train; but the foundation for this decision is not apparent from the information thus far available. The rear flagman appears to have obeyed the rule requiring him to go back to the tower and obtain permission for his train to proceed. He had apparently done this and either was on his way to place torpedoes still farther back from his train or else on his way back to the train itself when the mail train dashed past him. The fireman of the locomotive testifies that he heard two torpedoes just before his locomotive struck the standing train so that the only question as to the flagman is whether he succeeded in placing the torpedoes far enough back to give protection.

On this point it must be remembered that the flagging rule strictly interpreted really requires at times impossibilities. If trains are following closely together at high speed, a flagman may not have time to get 2000 ft. or even 1000 ft. in the rear of his train after it comes to a stop before the next train will come up.

The fact that stands out with most prominence in any investigation of this sort is that in emphasizing the flagging rule and neglecting the condition of the block signals, we are proceeding in the wrong direction to promote real safety in railway operation.

It is said that the reason why three trains in succession passed the danger signal at Western Springs was because there was a fog which prevented the enginemen from seeing the signal until they were close upon it. It is also stated, however, that the third train which caused the fatal collision was running at a speed as high as 60 miles per hour. What business has any train on any railroad to approach a home signal obscured by fog at any such speed? It may be perfectly safe to operate trains in this manner on a long, straight line in clear weather where an engineer can identify the signals at least half a mile back; but a fog wholly changes this condition. The only possible way in which trains can be operated at full speed with any reasonable safety in time of fog is to have every home signal interlocked with a distant signal at least 1200 to 1500 ft. in advance of the point where a stop must be made, and 1800 to 2000 ft. is better.

We are well aware that many of the manual-operated signal systems in this country are defective for high-speed running in that distant signals are not erected or are erected over only a part of the route, as was the case on this section of the C., B. & Q. system. Of course, if a road chooses to get along with a signal system of this sort, it can do so and still operate its trains with safety provided it will make and enforce the rule that whenever the weather conditions are such that a signal cannot be identified at a distance, the speed of trains must be reduced to correspond.

This is so simple and elementary a rule of signal engineering that it seems almost useless to set it down here were it not for the fact that not a few railway companies are operating high-speed trains under a block-signal system without distant-signal protection and justify the practice on the ground that they have at least applied something in the way of additional safeguard over the old-time train-order system with rear flagging

and that one has got to take some chances in railroading anyway. Every signal engineer familiar with foreign practice must realize that any such loose railroading would never be permitted for a moment on English or German railways.

It may be pointed out that there is a method by which such a line as that of the C., B. & Q. could be operated with reasonable safety under fog conditions. In clear weather it was very likely safe enough on these stretches of track with long tangents to allow the block-signal operator to give a clear signal to the tower in the rear as soon as a train had cleared the signal. In times of fog or storm it would be necessary to change this system so that the block-signal operator at Western Springs, for example, could not give a clear signal to the operator in the rear until she received word that a train had passed entirely out of the block ahead. Had such a rule been in force, the train which caused the collision of July 14 would have been stopped by the block signal at Hinsdale Springs, two miles in the rear. Of course, there would be admittedly grave danger in changing the method of operation of the block-signal system with changes in the weather. Inexperienced operators would be much more likely to make a mistake, but for the safe operation of trains some such overlap system must be installed in thick weather or else the speed of trains must be held down to a safe limit.

It may be instructive also to point out that the automatic-stop system, to which public discussion naturally turns at every accident under the block system, would not have prevented the Western Springs collision. Had the stop been placed at the home signal, the brakes would have been applied too late to stop the train before the collision occurred. It may be said that such an automatic stop should have been placed far enough back to stop the train before reaching the home signal. Since under the weather conditions prevailing, the engineer could not see the home signal until he was close upon it, the first thing to do would appear to be to put a distant signal far enough back so that the engineer himself could stop the train before reaching the point of danger.

A New Kind of Training for Engineers and a New Term — "Industrial Physics"

By Daniel F. Comstock*

There exists now in this country a constantly growing demand for a new kind of industrial training. The moving spirits of the great industrial corporations have come to realize that large financial returns may be expected from research laboratories or bureaus connected with their plants. There are already a large number of these laboratories in America. Prof. R. K. Duncan has obtained a list of 75 in the domain of chemistry alone and this is probably far from representative of actual conditions, for he states that because of the lack of definite statistical information "it was necessary to inquire here, there, everywhere among industrial colleagues for individual and incidental information."

A conspicuous example of a research laboratory, which is very wide in its scope and also very successful, is that of the General Electric Co., where the "annual expenditure passed the $100,000 mark several years ago," and where one product of the laboratory alone, the metalized filament lamp, "sold to the extent of over a million dollars in one year."

Now it is a fact that a large majority of the problems which industrial concerns desire to solve are not purely chemical, and many of them are more physical than chemical, and the consequence is that often the research chemist is confronted with difficulties which he cannot properly handle, or the problem at hand is considered insoluble. Suitable men for many of these laboratories are in fact hard to find. It is not necessary that most of these men know many technical details which are now parts of the established courses in engineering schools; it is not necessary for most of them that they be able to carry out complex organic analyses, for example, or that they know the various ways of winding generator armatures; but it *is* necessary that, besides a certain amount of originality, they have a good knowledge of the *principles of physics*, be thoroughly familiar with the *physical properties of materials* and finally have that attitude of mind, so valuable for this purpose, which we may call the industrial point of view.

All engineers know that a thorough knowledge of the *physical properties of materials* is extremely rare. Totally unsuitable materials are constantly being used in the construction of new machines or in the apparatus for new processes, and the consequence is that often a long series of costly approximations have to be made before the machine or process is satisfactory. Much of this inefficiency is totally unnecessary for the characteristics of the various materials are perfectly well known, but rarely to one man.

The physical properties of materials are not, therefore, secrets of nature, and what is needed is that the facts be coordinated and properly taught as a definite subject in our engineering schools. It would be difficult to overestimate the importance of such a course, if well designed, and a successful student would be a singularly valuable man.

The industrial point of view is also very important, for in this field a dingy little fact connected with lubricating oils may be just as powerful a limiting condition as the conservation of energy itself; and it generally takes the student of pure physics, used as he is to the logical category, a long time to appreciate this type of fact deeply enough to make it the basis for instinctive action.

At the present time, the scientific schools of the country make no attempt to give this kind of training. Physics is ably taught all over the country, but from the industrial standpoint the teaching is unsuitable. It is designed either for elementary training or for the future pure scientist or teacher. The problems considered are illustrative of fundamental principles, but they ignore most of those stubborn difficulties which cause the industrial man most of his trouble and they ignore almost entirely the *physical properties of materials*, because only the simpler properties have any theoretical importance.

This absence of problems more after the industrial type is reasonable and to be expected, because the new demand has not yet been brought clearly to the attention of educators.

The fact is important enough to reiterate that a very large number of the problems put up to the industrial-research man or to the engineer entrusted with the working out of a new machine or process are physical rather than chemical. A prominent manufacturer remarked recently: "Most of our problems are really in the domain of physics and our chemists are constantly attempting to solve problems for which they have had little training." At all events, we may be sure that we are not exaggerating when we say with M. C. Whitaker: "*Equally important* with chemistry is a knowledge of physics and its application." The italics are mine.

Notwithstanding the extreme importance of physics in modern industry and particularly where men are attempting to solve new problems and design new machines and processes, there has been no explicit acknowledgment that applied physics represents a domain in which it is becoming more and more important that men should be trained in our scientific schools. There is not even a term in common use at present to represent this domain as a whole, and until it is explicitly recognized and given a name, use will continue to be made in industry of men trained in other lines and not suited to the work at hand.

We need a definite term to hasten that crystallization into a recognized, separate entity, which is always necessary before

*Assistant Professor of theoretical physics, Massachusetts Institute of Technology, Boston, Mass.

the growth and development of a new subject is possible. I have advocated for some time among my colleagues "Industrial Physics" as the most appropriate term. This implies, as it should, the same general relation to pure physics that industrial chemistry bears to pure chemistry.

There should be courses in industrial physics in our engineering schools, including courses in the physical properties of materials. The school which first introduces such courses will have the satisfaction of seeing some of its graduates entering successfully a new field, which at present is greatly retarded in development by lack of men with the necessary training.

It is only through our schools responding quickly to new industrial needs that we can hope in the future to compete industrially with Germany, which, except for advantages dependent on natural resources, certainly excels us now.

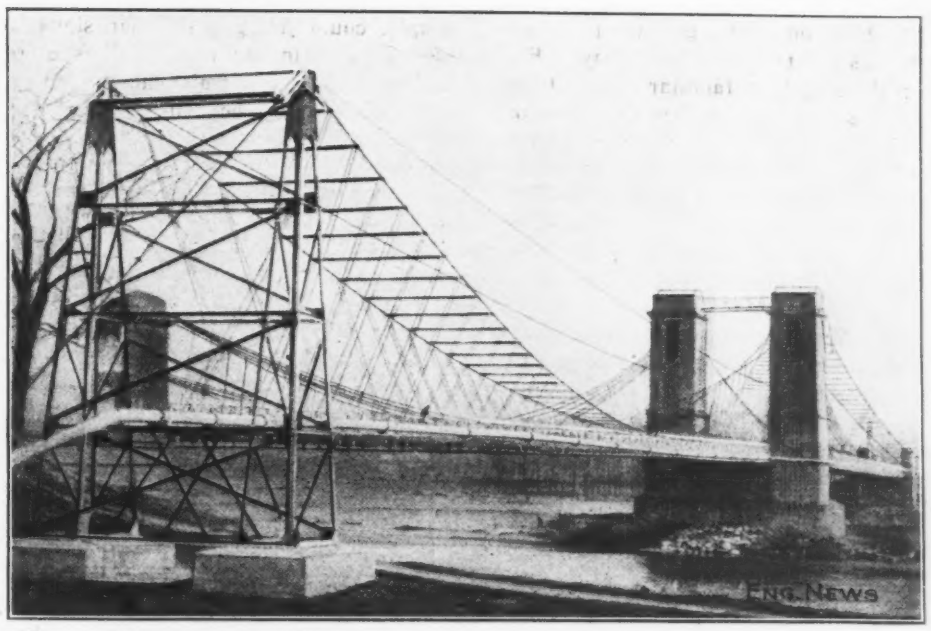


FIG. 2. VIEW OF SUSPENSION BRIDGE CARRYING WATER CONDUIT

A Water-Conduit Suspension Bridge, Feurs, France

The small village of Feurs, on the banks of the River Loire, in France, is supplied with water from wells driven on the opposite side of the river, so that it became necessary at the time of the construction of the water-works, to provide some means for carrying the conduit across the river to the town. As a result of the investigations carried on by tl Corps des Ponts et Chaussées, which had charge of the work, a suspension bridge utilizing one pier already in service on a highway suspension bridge, was built to carry the water conduits. A description of the construction appears in the March-April, 1912, number of the *Annales des Ponts et Chaussées*, by M. Betbeder Matibet, of the corps. From that article we have prepared the following brief extract.

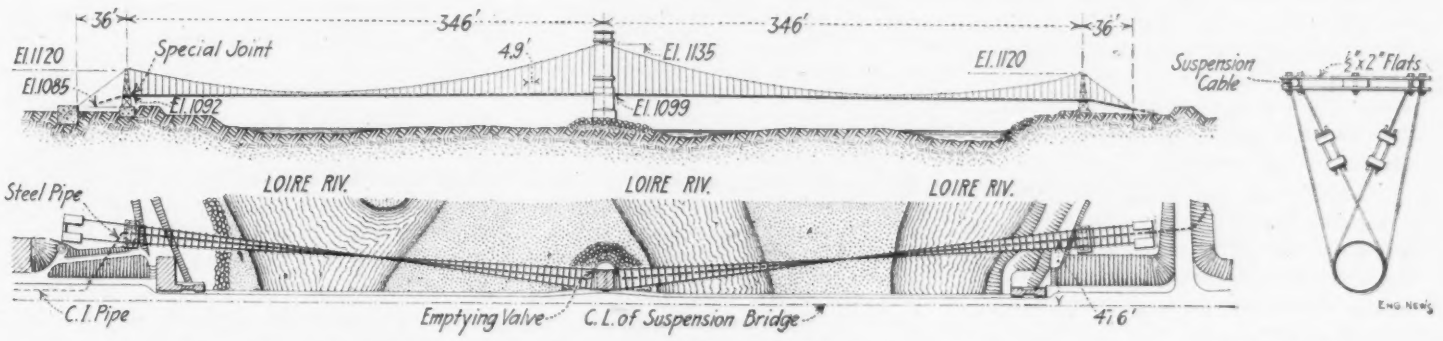


FIG. 1. HALF-PLAN AND ELEVATION OF WATER-CONDUIT SUSPENSION BRIDGE, FEURS, FRANCE

FIG. 3. DETAIL OF CONDUIT HANGER

On account of the instability of the river bottom, it was thought impracticable to attempt an inverted siphon for the crossing, and the project was not expensive enough to warrant the use of a tunnel driven by compressed air, so the engineers were forced to an over-head crossing.

The highway suspension bridge, which was in existence across the river at a proper location, was not of sufficient stability or steadiness to allow of its use for the conduit crossing, but its central pier was of such width that it could be utilized for the central pier of an entirely separate suspension bridge, carrying the water conduit alone.

Fig. 1 shows the elevation and half plan of the new bridge. The center pier shown in plan is half of the pier carrying the highway suspension bridge, and supports one set of the cables of that bridge. The suspended span extends on either side of the center piers at angles of 15° 25′ from the central longitudinal axis of the highway bridge, to new steel towers erected on either side of the river.

The main suspension for the conduit bridge is made up of two cables (size not given in article) suspended from anchors fastened to the side of the central tower, and crossing, as shown in the plan, to the opposite side of the shore towers. The conduit itself is slung from these cables by means of crossed smaller cables attached to cross-bars bolted tight to the main cable, as shown in Fig. 3. This double crossing of the main suspension cables and of the hanger cables, adds much to the stiffness of the structure. Fig. 2 is a view of the bridge looking toward the common center pier.

The conduit itself is an 8-in. steel pipe of ¼-in. metal, made in 21-ft. lengths, and joined with a flanged joint calked with hemp and tightened with 12 bolts. The expected pressure in it is about 57 lb. per sq.in., but it was tested before use up to 140 lb. per sq.in. It is provided at either end with special expansion joints, not shown in the figures, and has also, at the center pier where it passes around the masonry (as shown in Fig. 1) an outlet valve to blow off the air that might collect at this highest point in the conduit.

The conduit passed through the cold winter of 1910-1911, and the hot summer of 1911, with perfect success. During very cold weather, the water is drawn off so as to avoid freezing. This structure was built under the direction of M. Backes, a specialist in suspension-bridge work. The whole structure cost about $5200 (26,000 fr.).

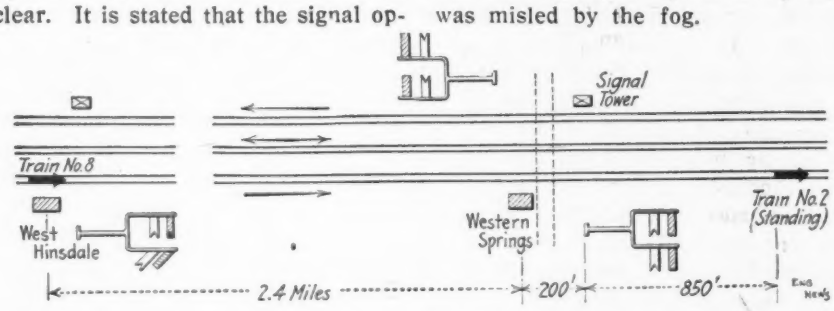
The Western Springs Collision on the C., B. & Q. R.R.

As noted briefly in our issue of July 18, another disastrous rear collision has occurred on a line equipped with block signals. This accident occurred about 6:45 a.m., July 14, on the Chicago, Burlington & Quincy R.R., at Western Springs, 15½ miles from Chicago. The manually operated block signal here was displayed at "stop" against a fast ten-car passenger train (from Denver), but the train overran the signal and when stopped it was out of sight of the signal cabin, owing to a fog. The signal operator notified the next tower in the rear that the train had passed, and the operator at that tower gave a clear signal to a following fast train of empty mail cars (with no passengers). The signal at Western Springs remained at "stop" but the second train also ran past it and dashed into the standing passenger train, smashing the rear sleeping car and overturning the next sleeper. The engineman of the second train was killed and the fireman was badly injured. Of the persons in the rear car, 12 were killed (including the porter), while about 16 persons in the two damaged cars were injured more or less severely. The conductor, who was standing beside his train, was injured by the flying wreckage.

The line is perfectly straight for a long distance on both sides of the scene of the accident, but there is a sag in the grade west of Western Springs station. There are three main tracks, all protected by signals. The block-signal equipment was installed on this division 22 years ago, and this is the first fatal accident in which the signal system has been involved. The signals are of the semaphore type, manually operated, and the installation is as shown in the accompanying sketch plan. At each block there is a tower and a pair of bracket-post signals, for movements in opposite directions. The bracket post carries two masts, each with two semaphores. The signals on the right-hand mast of the bracket govern movements on the main track; those on the left-hand mast govern movements on the middle track, which is a relief track used for movements in both directions. Each mast on the bracket post carries two semaphore arms, the lower one being fish-tailed. When both arms are horizontal the indication is "stop" for all trains; if the upper arm alone is lowered, it gives a permissive "proceed" signal for freight trains only. There is no doubt that at the time of the accident both arms were horizontal. Inspection of the scene of the accident shows that there is no distant signal in this block, although several other blocks are thus equipped.

Between Western Springs and West Hinsdale (the next block station) 2.4 miles, there is a sag in the grade, where the line crosses swampy ground and it appears that mist rising from this low ground obscured the view of the signals at Western Springs. The rules provide that when a train overruns a "stop" signal before coming to a stop, it must not back up, but the brakeman must go back to the tower for orders, and, if necessary, go back the prescribed distance to set torpedoes. The signal operator must notify the dispatcher of all such cases.

Three trains in succession overran the stop signal at Western Springs on the morning in question, but the first one (prior to the accident) at once proceeded on its way. The second train to overrun the signal was the passenger train, presumably through failure to see the signal in time; this signal had been set at "stop" for the reason that a freight train on the same track was pulling out at a crossover at the next tower to the east (Congress Park). The passenger train was pulled up and came to a stop with its rear end about 850 ft. beyond the signals, or 1050 ft. beyond the station. The rear brakeman went back to the tower, but the evidence as to his action is not clear. It is stated that the signal operator told him that the train could proceed, as Congress Park had given a clear block (which was the case). The brakeman claims that after leaving the tower he went farther back and set torpedoes on the track. But just when he went back, or how far he went, is not certain. He knew the other train was following, but may have thought it would be on the middle track and therefore have been careless in flagging.



SKETCH PLAN SHOWING CONDITION OF SIGNALS AND TRAINS IN THE REAR COLLISION AT WESTERN SPRINGS ON THE C., B & Q. R.R.

After the passenger train ran past the signal at Western Springs (and was out of sight of the tower on account of the fog), the operator notified the operator at West Hinsdale that the train had passed. The latter operator therefore set his signal at clear for the following mail train, which was about nine minutes behind the passenger train and was running probably about 60 m.p.h. The evidence seems to indicate that the fog west of Western Springs shut out the view of the signals, but that at some point near the station the engineman shut off steam and applied the brakes, evidently having got sight of the "stop" signal. There is conflicting evidence (as is usually the case) as to whether the brakes were applied or the steam shut off; and this point probably never will be cleared definitely, as the engineman was killed and the shock and bodily injury to those able to give evidence may well prevent any clear recollection of what was felt or noticed at the time. If the brakes were applied, it is doubtful whether an emergency application was made, and in view of the wet and slippery condition of the rails, it is thought likely that the engineman would not do this, believing that it would only slide the wheels and reduce the efficiency of the brakes. Even if he had done so, however, the collision would have occurred, in all probability, since this train with its high speed would probably have required 1800 ft. to make a stop (instead of the approximately 1000 ft. available).

The signal operator (a woman) had been in the service several years and was considered trustworthy. The engineman of the second train was a man of long experience, and seems to have run past the signal because (on account of the fog) he did not see it in time. No explanation has been given as to why the engineman of the first train also overran this signal, but presumably he also was misled by the fog.

The railway company's official investigation was made by a board of its officers. The Illinois State Railway Commission participated in this, by special invitation of the railway, and the Interstate Commerce Commission also was represented. We are indebted to officers of the railway company who have furnished such information as was available at the time. Following this investigation, the company issued a statement placing the blame directly upon the flagman of the first train, for failure to protect his train; and secondarily upon the engineman of the second train for overrunning the signal. Nothing is said as to the engineman of the first train, who also overran the same signal, but who had pulled up as soon as possible. The inference is that the board considered that this man was not liable to blame, but that the man on the second train did not act with sufficient vigilance or promptitude. The official statement is as follows:

"The evidence shows the accident was caused by failure of the flagman of train No. 2 to properly protect his train against mail train No. 8. The engineer of mail train No. 8 contributed toward the accident by running by the block signal set against him at Western Springs."

Annual Meeting of the National Municipal League

The eighteenth annual meeting of the National Municipal League was held at Los Angeles, Calif., July 8 to 12. The meeting was unique in that a large part of the regular program was devoted to subjects related to the new city charter for Los Angeles. In addition, a whole session and a round-table luncheon discussion were devoted to the charter draft.

The keynote of the meeting was the Civil Service with particular reference to the election and retention of experts for the higher municipal executive offices. Next to and closely related to this was the prominence given to the need for efficiency as well as honesty in municipal government. Much was said during the meeting concerning various phases of commission government. This was natural not only because of the rapid progress which the commission plan has been making of late, the number of cities which have adopted the plan having increased from about 200 to 250 since Jan. 1, 1912, but also and chiefly because the commission plan is proposed for Los Angeles.

More than 30 papers were on the program, besides the informal discussions at round-table luncheons, which have been one of the most successful features of the meetings of the League for many years past. But few of the papers dealt even directly with strictly engineering questions, but many of them touched upon subjects of vital importance to engineers in the municipal service.

EXPERT ADMINISTRATION THROUGH THE CIVIL SERVICE—The keynote of the meeting, as already mentioned, was sounded by William D. Foulke, of Richmond, Ind., in his annual presidential address, which was entitled: "Expert City Management." The whole address was a plea for the employment of trained men in municipal administration, selected under civil-service rules, the latter even extending to the heads of the executive departments. The local civil-service rules should be subject to the approval of the state civil-service commission. The civil-service provisions of the proposed Los Angeles charter, as thus far drafted, were mildly criticized as being inadequate. Doubt was expressed as to the possibility of securing efficient government through commissioners elected to perform the joint duties of the legislative and executive branches of city government.

Later in the meeting, Elliott H. Goodwin, of New York, read a paper on "The Need for an Adequate Civil Service Law." Mr. Goodwin was also of the opinion that local civil service should be in a measure subordinate to state control, and stated that this is impossible in those Western states where municipal home rule has been carried to an extreme. Civil-service commissioners should be appointed for six years, with terms overlapping. They should be removable only after a hearing and should have power to establish civil-service rules after a public hearing and without the necessity of approval by the mayor and council. Like President Foulke, Mr. Goodwin strongly favored the selection of higher administrative officials under civil-service rules. Both of these speakers, however, indorse the plan of having examinations for higher places conducted by a special committee chosen because of its knowledge and experience in the same lines as the candidates. Both agreed that much weight should be given to the technical training and experience of the candidates.

Mr. Goodwin's paper, like Mr. Foulke's address, was in direct line with a report of a joint committee of the National Municipal League and the National Civil Service Reform League on the selection and retention of higher municipal officials, both men named being members of the committee. The report was submitted by Clinton Woodruff, of Philadelphia, chairman of the committee.

In the course of his annual review of the trend of municipal progress, which was entitled "Simplicity, Publicity and Efficiency in Municipal Affairs," Secretary Woodruff spoke of the growing use of trained university men in municipal administration. In accordance with an offer of aid from the provost of the University of Pennsylvania, a number of engineers connected with the faculty of that institution are now giving assistance in the water-works and highway service of the city of Philadelphia.

After questioning the wisdom of choosing executive officers by popular vote, as is attempted in the case of members of the commission in the commission plan, Mr. Woodruff told of a proposition now being urged in Indiana. This contemplates 15 municipal councilors, elected at large on the nonpartisan basis, who would appoint a mayor and four commissioners to be at the head of all the administrative work of the city. The latter board would appoint all subordinate officials. Provision would be made for small civil-service and election commissions. Appointive officers of all grades, it appears, would be subject to recall by a two-thirds vote of the city council, provided that the recall was requested by popular petition.

In the course of a paper entitled "Honesty Plus Efficiency in Municipal Government," Meyer Lissner said that much reform has been achieved so far as honesty is concerned, but to honesty must be added a sense of and a demand for efficiency. The commission plan attempts to secure the election of honest officials but does not go far toward the selection of efficient officials. Experts are employed in private business but demagogues make light of the employment of experts by municipalities. A city councilman recently said: "Them experts is all corporation men." Mr. Lissner voiced the sentiment expressed by many other speakers at the meeting to the effect that the technically trained man so essential to efficient municipal administration cannot be secured by popular election.

COMMISSION GOVERNMENT FOR LARGE CITIES—Los Angeles being a larger city than has yet adopted the commission plan and so much of the proceedings of the convention being prompted by the proposed Los Angeles charter, it was very appropriate to consider whether or not the commission plan bids fair to be as well adapted for large as for small cities. In a paper dealing with this subject, sent by Prof. William B. Munro, of Harvard University, it was stated that less than half of the commission cities have populations of more than 5000, while only a few have populations of more than 100,000. It is claimed that commission government makes it possible to secure better men for office. This statement does not lend itself to statistical proof, but a study of ten cities indicates no material change in the personnel of the 50 men heading the government of those cities. Men of the same caliber achieve better results through the improved governmental machinery of the commission plan. It is also claimed that the commission plan reduces municipal expenditures. As a rule, this has not proved to be true in the ten cities studied, but better results have been had for funds expended than were had under the old plan. The theory of the commission plan is that broad-gage amateurs, with no technical training, will head the various city departments, and that these will select trained executive officials. A few cities elect commissioners to fill a specific office. In such cases the popular idea is that men of training and experience can thus be secured. The results are likely to be a selection of second-class technical men instead of good, all-round, broad-gage municipal administrators. The final conclusion of Professor Munro's paper was that, aside from placing responsibility, the chief promise of success of the commission plan lies in its being linked with other features of municipal government not necessarily a part of that plan.

MUNICIPAL FINANCES AND TAXATION—A long session was devoted to this general subject. Mr. Hydecker, of New York City, in treating of taxation, advocated the assessment of property at its full value and suggested that assessors should take into account the depreciation of buildings. Attempts to assess personal property for local purposes should be discontinued. Real estate should be the basis of local taxation, because municipal expenditures are reflected in land values. The main burden of taxation already rests on land and efforts should be made to perfect methods of assess-

ment. To this end land-value maps and books of building values are helpful.

Taxation was treated in a paper sent by Prof. Carl C. Plehn, of the University of California. The author expressed himself strongly against what is known as local option or home rule in taxation. He advocated the employment of a larger number of expert tax officials, the adoption of better methods of taxation, full valuation of property and publicity.

"Budget Making" was the subject of a paper by Jesse D. Burks, Director of the Philadelphia Bureau of Municipal Research. Budget making is an essential feature of the adoption and realization of a well conceived municipal program in line with the present demand for social reforms. Besides means or methods for choosing good men for office and holding them responsible to the people and giving the voters the power of controlling municipal legislation, efficient municipal government demands intelligent citizens with a definite will to express and specific means of determining whether or not that will is being carried out. As a means to this end, the budget is essential. Rightly framed, it reflects community needs and also the degree to which they are being met.

Supplementary to the paper just mentioned, was one on "Revenue Accounting," by Dr. L. G. Powers, U. S. Bureau of the Census. The author showed how an adaptation or commercial method for keeping expenses within revenue may be utilized to reduce the tax rate.

Closely allied to the subject of taxation was a report on "Excess Condemnation," presented by Robert S. Binkerd, Secretary of the City Club of New York and chairman of a committee on the subject named. The principle and practice of excess condemnation was approved by the committee, both as a matter of municipal economy and as a means of controlling the character of real-estate developments fronting upon municipal improvements. A decision of the United State Supreme Court indicates that excess condemnation is not a violation of the Constitution of the United States. In some of the states, where state courts have put a narrow interpretation upon state constitutions, amendments to those documents are necessary and attempts should be made to secure them.

HEALTH AND HOUSING—In a paper entitled "The Municipal Health Problem," M. N. Baker, Editor of ENGINEERING NEWS and President of the Board of Health of Montclair, N. J., pointed out the need for more general education in health matters, and urged that for the present the work of municipal health departments should be concentrated upon the control of communicable diseases and the reduction of infant mortality. Works of sanitation and municipal cleansing should be entrusted to other branches of the city government. As a means of testing the efficiency of the health-department work and of indicating what branches should be extended and what curtailed, a form of classification of health-board expenditures was submitted. This form divided all such expenditures into three classes: (1) Direct and (2) indirect health-protective work, and (3) general. Such works of municipal and private cleansing as collection and disposal of garbage, ashes and other refuse, the reduction of flies, mosquitoes and rats, plumbing inspection and the suppression of bad odors, noises and other general nuisances, which are annoying rather than unhealthful, would, in this classification, be placed under indirect or remote health-protective work.

Touching upon the latest draft of the Los Angeles charter, the author pointed out that the proposed plan of having the executive health officer subordinate to the commissioner of public welfare, who, in turn, would exercise control over health matters jointly with the other seven commissioners, presented obstacles to efficient, progressive public-health work. These obstacles are made all the greater since health legislation is exercised by the commission as a whole instead of being vested in the health department and is also subject to popular control through the referendum or the initiative. Under such conditions, the health officer, before he can secure necessary powers for what he considers to be needed for health-protective work, may be called upon first to educate the commissioner to whom he is a subordinate. If he succeeds in this, he may be compelled to educate the other six commissioners and finally he may have to educate a majority of the electorate. In addition to all this, he is subject to popular recall at any time. Under such a governmental scheme of public-health administration, education of the voters, which is essential under any form of municipal government, becomes doubly important.

John Ihlder, Field Secretary of the National Housing Association, discussed the broader phases of housing reform and showed the advantages both in theory and practice of voluntary local organizations. In the larger cities such organizations should have the service of a trained and well paid executive officer. Rev. Dana W. Bartlett, of Los Angeles, made a plea for homes rather than for mere housing. A house to each family with some ground about it was held up as an ideal. The removal of factories from crowded cities to more open sites is a means to this end and has been made possible by improved means of transportation and improved freight-handling facilities. A garden city of 3000 acres has been laid out five miles north of the Los Angeles harbor, Olmsted Bros. having been employed for this purpose.

CITY PLANNING AND COMMISSION GOVERNMENT—Ernest Bradford, of Washington, D. C., expressed, in a paper on this subject, the belief that the improvements in city government incident to the commission plan will facilitate much needed city planning and that this in turn will help to solve the housing problem discussed in previous papers. City planning in turn will contribute toward the efficiency of commission government because it involves a well conceived municipal program.

HOME RULE IN CITY AND COUNTY—The history, principles and practice of municipal home rule in California were set forth in a paper by Prof. Thomas E. Reed, of the University of California. By home rule was meant the power of each city to frame and amend its own charter with absolute freedom from legislative interference. In a limited way this privilege was secured through the state constitution of 1879. The provision was copied from the constitution of Missouri, enacted four years earlier. In both states home rule was granted only to the largest cities. This has since been extended until now any California city of 3500 population and upward may, by motion of its own citizens, cause the creation of a charter-framing board, known as the Board of Freeholders. These boards consist of fifteen members and within 120 days of their appointment must draft a charter and submit it to the city council. The council, within 20 to 40 days, must submit the draft to popular vote. If the vote is affirmative, the document goes to the state legislature for enactment. Altogether, 31 cities have framed charters by this means and some more than one charter. The legislature has never failed to approve one of these charters. In fact, only once has a dissenting vote been recorded and then a single vote was cast on the belief that the charter in question was unconstitutional.

The Los Angeles charter of 1903, framed by the method just outlined, contain the trilogy known as the initiative, the referendum and the recall, which has since been adopted so widely by cities throughout the country, including "far-famed Des Moines."

The Sacramento charter, Professor Reed said, provides for the shortest ballot on earth: five commissioners, who serve *ex-officio* as a board of education. The terms of office being five years, only one commissioner is elected each year and thus only one municipal office is filled annually by election.

The movement for county home rule in California by means of county charter-framing freeholders, was described by Leslie R. Hewitt, of Los Angeles. Percy V. Long, City Attorney of San Francisco, reviewed the history and experience of San Francisco as a combined city and county. Until quite recently this city was the only example of complete consolidation of city and county government in the United States. The consolidation re-

sulted from the petition of the citizens to the legislature of 1856. At that time there was a good county government, but a very bad city government, and accordingly the abolition of the city government was requested. After many years of struggle, San Francisco finally adopted a home-rule charter in 1900. The framers made the mistake of inserting too many details in the charter.

Richard S. Childs, Secretary of the Short Ballot Association, New York City, stated that most county governments are like an automobile with a motor to drive each wheel. He advocated the short ballot with coördination between the county and state government. The state should appoint men who execute state laws.

STATE VERSUS MUNICIPAL REGULATION OF PUBLIC UTILITIES—This subject was discussed jointly by John M. Eshelman, of San Francisco, President of the Railroad Commission of California, and Lewis R. Works, former President Los Angeles Board of Public Utilities. Mr. Eshelman, as perhaps might be expected from the head of a newly created commission which has been given strong powers to regulate all public-service corporations in California, spoke in favor of state rather than municipal control in all except purely local matters. He also advocated state control of municipally owned and operated utilities, in so far as they supply customers outside their own boundaries. Mr. Works dissented from the latter principle, but agreed in considerable part with the idea of state control as applied to private corporations. For the larger cities, however, he advocated considerable if not a full measure of control by local public-service commissions.

OTHER PAPERS—Among other papers presented there were two dealing with the political boss and one on Socialism. Prof. A. B. Hart, of Harvard University, in a paper entitled "The Bosses' Day in Court," impersonated a political boss addressing an audience of political reformers and explaining how his methods were superior to theirs. The part was well taken. Chester H. Rowell, of Fresno, Cal., spoke on the "Elimination of the Party Boss in California Cities." The process was begun in Fresno by the adoption of a home-rule charter, which did away with parties in municipal elections.

In introducing a paper on "Socialism in California Municipalities," Prof. Ira B. Cross, of Stanford University, stated that there are now 1100 to 1200 Socialists holding public office in the United States. The party has made progress in California during the last two years and would have carried the last election in California had it not been for the McNamaras' confessions a few days before the election. The result of Socialist administration in California cannot readily be judged either because the Socialists are not in full control, except in one city, or because local conditions have been such that they could effect comparatively little change in methods and results.

Two papers on street-railway franchises, by Delos F. Wilcox, of New York City, and J. W. S. Peters, of Kansas City, Mo., will be given consideration in a later issue.

THE PROPOSED LOS ANGELES CHARTER—The two concluding sessions of the meeting were devoted chiefly to a discussion of the proposed new charter for Los Angeles, which provides for the commission plan of government, with variations. A copy of the latest draft of the charter, now being framed by a Board of Freeholders, was placed in the hands of a considerable number of members of the League, each of whom was called upon for his opinion on various mooted questions pertaining to the provisions of the charter. Orderly procedure was secured by this means and by taking up the questions, which had been printed and distributed in advance, in their stated order. Features of the discussion were strong expressions in favor of the civil service, of a city business manager, and of the coördination of the engineering work of the city.

The Second Law of Thermodynamics in the Atmosphere*

BY CHARLES P. STEINMETZ†

THE SECOND LAW—The second law of thermodynamics may be expressed in the form: "In any cyclic process, the sum total of unavailable heat energy increases." Thus, if we transform electrical to mechanical energy and backwards, we do not get back the total amount of energy, but some of it is converted into heat. Of this heat energy at least a part can never be retransformed into any other form of energy, i.e., it has become unavailable. Or the law may be expressed: "Without expenditure of some other form of energy, heat flows only from higher to lower temperature;" that is, from a higher heat level to a lower heat level. In this form the law is easiest to grasp; just as water, without expenditure of outside energy, flows only from higher to lower level.

The result thereof is that the total heat energy can never be used in any case; but that amount which is still heat energy when the lowest heat level or temperature has been reached cannot be transformed except by the use of additional energy, i.e., it has become unavailable. Thus of the total heat energy in the superheated steam issuing from the boiler, only that corresponding to the temperature range from admission temperature to the temperature of surrounding space can be used; but the much larger amount of heat energy which is still contained in the steam exhausting into the condenser at atmospheric temperature is unavailable.

To some extent availability is relative. The heat energy in the steam exhausting into the condenser at atmospheric temperature, which is unavailable under ordinary conditions, would be available in part if we could exhaust at the temperature of liquid air; and of the heat energy remaining in the exhaust at liquid-air temperature, a further part could be transformed by exhausting at the temperature of liquid hydrogen, etc. Even between the limits of atmospheric temperature appreciable variations of available energy, and with it differences in the efficiency of steam turbines, etc., are noticeable. However, the total heat energy could be made available only by dropping down to the absolute zero of temperature, and as this cannot exist, all the energy, which is still heat energy at the minimum temperature of the universe, has become absolutely unavailable, i.e., it can never be used without the expenditure of some other form of energy.

An analogy is given by water power. Of the energy of a water course, only that represented by the difference in height between the upper level and the lower level is available at the point of development. However, some miles distant, a still lower level may exist, and further hydraulic energy made available by it; but finally the ocean level is reached. Here the water still contains an enormous amount of gravitational energy—that corresponding to its distance from the center of the earth. This, however, is now absolutely unavailable, since no lower level exists into which the water can be discharged, and outside energy would have to be expended to make such a lower level.

LEVELING OF ENERGY—The result of this functioning of the second law of thermodynamics is that the temperature crests in the universe are leveled off, the temperature valleys filled up, the amount of unavailable heat energy (that below the bottom of the temperature valleys) is increased; in other words, the temperature of the universe tends toward a uniformity, at which all the heat energy has become unavailable. The temperature differences in the universe are thus maintained only through the expenditure of other forms of energy, and other energy is thus continuously poured into the gulf of heat energy in producing available heat energy through temperature differences, which again are continuously leveled off and the heat energy made unavailable by the functioning of the second law of thermodynamics; but no return path exists from the unavailable heat energy to other forms of energy.

The outcome of this unidirectional transformation law must be that finally all the other forms of energy will have

*From "General Electric Review," July, 1912.

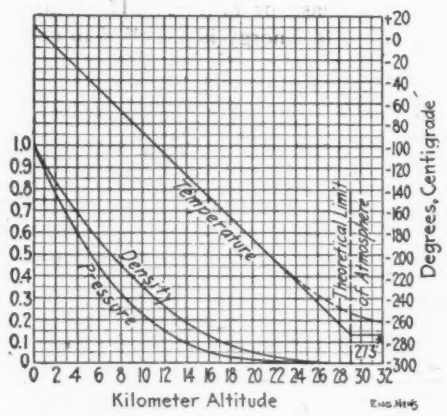
†Chief Consulting Engineer, General Electric Co.

been converted into heat energy, and all the heat energy have assumed a uniform temperature level, i.e., become unavailable. This means that all the energy of the universe must finally be converted to unavailable heat energy, and, if the second law of thermodynamics holds universally, no return exists from this state; hence, the universe must finally run down, just like a clock. All energy transformation will stop, i.e., all motion will cease and the universe will be dead. The energy will still be there—the law of conservation of energy will not have been offended—but as unavailable heat the energy will be dead. It is true that if we define energy as that entity which can do work, it is questionable whether the unavailable heat energy of the dead universe, which can never do the work, can still correctly be called energy.

WILL THE WORLD RUN DOWN?—The second law of thermodynamics is well founded on our experience. The reasoning from this law as to the death of the universe is logical. At the same time, the conclusion that the universe must run down is not reasonable. If the universe is eternal, has existed since Infinite time, then it should have run down an infinite time ago. But if it is not eternal, but had a beginning, what was before? How could energy begin without offending the first law, that of the conservation of energy? Thus, in the final reasoning, we arrive at a contradiction.

The explanation may be either that we have attempted to reason beyond the limits of the capacity of the human mind, which, being finite, always fails in the attempt to reason into the infinite, or it may be that the second law of thermodynamics is not of universal application, is not a general law of nature, but is of limited application only. In the following I wish to show that the latter is the case. A single exception obviously would be sufficient to show that the second law of thermodynamics is not a universal law, and that the conclusions regarding the death of the world, based on this law, are thus not justified. As the thermodynamics of gases is far simpler and more completely known than any other branch of thermodynamics, it would offer the most promising field of study.

MOLECULAR VELOCITY EXCHANGE—The kinetic theory of gases is probably as fully and conclusively proven as anything can be by the inductive method of science. According to this theory, the heat energy of a gas is the mechanical energy of the irregular molecular motion: the $\frac{1}{2}mv^2$ of the molecules and the atoms in the molecules. The second law of thermodynamics then is nothing but the application—the natural consequence of the operation—of the law of probability. If we bring together two gases of different kinetic molecular energy, i.e., of different temperature, such as a liter of air at 30° C. and a liter of air at 10° C., in such a way that the molecules can exchange their motion, i.e., heat can flow between the gases, it is obvious that, in an interchange of velocity between the molecules, one having a velocity above the average is more likely to lose than to gain velocity; a molecule with less than average velocity is more likely to gain than to lose velocity. The result of the interchange of velocity—or rather of kinetic energy, in accordance with the laws existing between bodies, probably the law of gravitation—thus is an averaging of the kinetic energy, i.e., an equalization of the temperature—in the above instance to 20° C. for both liters of air. However, the result of the operation of the law of probability cannot be a perfect equalization of the molecular energies so that all the molecules have exactly the same energy, but sometimes a fast molecule may still gain energy (although it is more probable to lose), or a slow molecule may lose. The result thus would be



CURVES SHOWING THEORETICAL CONDITIONS FOR THERMODYNAMIC EQUILIBRIUM IN ATMOSPHERE (FOR SURFACE TEMPERATURE OF 10° C.)

a distribution of the kinetic energies between all the molecules in accordance with the probability law; and the temperature then represents, or is, the average kinetic energy of the molecules—is represented by an average molecular velocity. This is probably found most frequently among the molecules; but all higher and lower velocities exist, becoming, however, more and more rare the further they differ from the average velocity, in accordance with the probability law.

THE SORTING "DEMONS"—Causing heat to flow from a lower to a higher temperature then means separating the faster from the slower molecules. Experience, expressed by the second law of thermodynamics, says that this can be done only by the expenditure of outside energy. However, such a separation of the fast from the slow molecules without expenditure of outside energy would in no way contradict the law of conservation of energy, as Maxwell has shown. Assume that we have a volume of gas at constant temperature—the two liters of air at 20° C. resulting from the previous illustration—and have a partition to divide the gas volume in two parts. This partition may be perforated by numerous minute doors, which we assume to have no weight and to move without friction, so that no energy is required to open and close them. Assume now that at every such door we place a demon, who opens the door whenever a fast molecule comes from the right, or a slow molecule from the left, and lets this molecule through; but does not open the door for a slow molecule from the right or a fast molecule from the left. The result would then be, that gradually the fast molecules would accumulate in the left, and the slow molecules in the right section of the space; that is, without expenditure of outside energy, but through the intelligence of the demons, heat energy would flow from the lower temperature on the right to the higher temperature on the left side of the partition, against the second law of thermodynamics.

A REAL "DEMON"—Now these demons exist in nature. Every cosmic body is such a demon, and separates the fast from the slow molecules, keeping the latter and sending the former out into space, and thereby causing heat energy to flow into space at a temperature far above its own temperature. Consider, for instance, our earth. In the uppermost regions of the atmosphere, assume a molecule which happens to be moving in an upward direction, and does not happen to approach another molecule so closely that its direction of motion is changed. Such a molecule will move upwards, until its motion is stopped by the force of gravity, by the attraction of the earth, when it falls back again. If, however, the upward velocity of the molecule is sufficiently high—above a certain critical value—then this molecule escapes from the attraction of the earth into space, and never comes back. This critical velocity at which a molecule escapes from the earth is 11,000 meters per sec. Assuming the average velocity of the molecules of the air, corresponding to an average terrestrial temperature of 10° C. or 283° abs., as 750 meters per sec., then the velocity of 11,000 meter-seconds corresponds to a temperature of

$$283 \times \left(\frac{11{,}000}{750}\right)^2 = 60{,}000° C.$$

That is, the molecules which the earth sends out into the universe have a kinetic energy corresponding to a temperature of 60,000° C.; or, as we may say, by the escape of these molecules, heat energy flows from the temperature of the earth, 10° C., into a temperature of 60,000° C.

IS INTERSTELLAR SPACE COLD?—This brings up an interesting feature. Since the temperature of the earth steadily decreases with the increasing altitude, we usually think of cosmic space as extremely cold—near the absolute zero of tem-

perature. Empty space obviously has no temperature, since temperature is an attribute of the matter in space. Judging the temperature of cosmic space by the kinetic energy of the molecules which have escaped into space from the larger cosmic bodies and which traverse space in irregular motions, we would be led to the conclusion that, far from being extremely low, it would, on the contrary, be of an inconceivably high value, probably several hundred thousand degrees Centigrade. This conclusion would better agree also with the very simple line spectra of gaseous matter in space, as shown by the nebulæ.

LIMIT OF HEAT CONCEPTION—We may ask, however, whether the kinetic energy of a molecule which, due to its high velocity, has escaped into cosmic space, can still be considered as heat energy. Heat energy is the kinetic energy of irregular molecular motion. The difference between the heat energy of a gas and mechanical energy thus lies in the irregularity of the motion and the size of the moving particles, which is such that only the resultant effect of the mechanical motions of large numbers of moving particles can be perceived. Irregularity of motion, however, is relative; for, if we consider a single molecule which has escaped into space by reason of its high velocity, we cannot attribute any irregularity to its motion. That is to say, its kinetic energy cannot further be considered as heat energy; but the kinetic energy of the molecule, which was heat energy while the molecule moved in a mass of gas together with other molecules, is mechanical energy of cosmic motion, and the molecule is a cosmic body, traversing space under the laws of gravitation, but not subject any more to the law of probability of mass action, i.e., to the second law of thermodynamics.

This brings us to the question of the limitation of the conception of heat energy, but for this purpose we do not need to go to cosmic space. If we consider the vacuum tube, and go to the highest vacua—the cathode-ray vacuum and beyond—the distances between the molecules become so large that the free path of each molecule becomes appreciable, and the action of the kinetic energy of the individual molecule becomes noticeable. But as soon as this is the case, the kinetic energy of the molecule cannot well be considered as heat energy any more, and the laws of thermodynamics, which, after all are the laws of probability of a mass of moving bodies, begin to fail in their application. Thus Crookes proposed to recognize this condition of a high vacuum, where the molecules act as individuals, as a fourth state of matter. This again throws a side light on the question of the temperature of the cathode-ray tube, or the mercury arc in a vacuum. At these very high vacua we may say that we cannot speak of a temperature at all, and heat energy, as the resultant mechanical energy of molecular motion, ceases to exist with the separation of the molecules to such distances that their resultant effect vanishes when compared with their individual actions. When, however, the kinetic molecular energy ceases to be heat energy, the second law of thermodynamics, which is the application of the law of probability, also ceases.

TEMPERATURE EQUALIZATION NOT UNIVERSAL—Spontaneously, heat energy flows from a higher to a lower temperature, until equality is reached, and most methods of heat measurements are based on this law. However, even this law is correct only within certain limitations. For instance, in the atmosphere of our earth, where there is continuous interchange of heat energy and the air is never at rest, nevertheless no equalization of temperature occurs, and there is no tendency to a condition of equilibrium at constant and uniform temperature. The condition of equilibrium is a definite and very decided decrease of temperature with increase of altitude. If we assume that no heat energy is supplied to or withdrawn from our atmosphere, and that the atmosphere is very thoroughly mixed so as to reach equilibrium condition, then (if for a moment we leave out of consideration the effect of condensation of moisture) the equilibrium condition would be a uniform decrease of temperature with increasing altitude, down to the absolute zero of temperature at an altitude of about 29 km. (about 18 miles). As function of the altitude, the theoretical equilibrium condition of temperature, air pressure and air density are shown in the diagram herewith, assuming 10° C. as surface temperature. The reason for this is obvious. In the equalization of temperature, whether by the molecules in bulk, in air currents, or by the motion of individual molecules in heat conduction, any upward motion of a molecule is accompanied by a retardation due to the attraction of the earth, and thereby a decrease of kinetic molecular energy, i.e., of temperature. Any downward motion is accompanied by an acceleration by gravity, and consequently by an increase of kinetic molecular energy and therefore of temperature, and equality of temperature throughout the entire atmosphere is thus impossible with freely moving molecules: the theoretical condition of equilibrium is the temperature distribution with the altitude, in accordance with the adiabatic law.

"DEMON" ACTION IN UPPER AIR—In accordance with this theoretical law of atmospheric equilibrium, the atmosphere would have a finite limit at about 29,000 meters, at which limit air pressure, density and temperature fall to zero. We know, however, that an appreciable atmosphere extends very far beyond these limits, and for the upper regions of the atmosphere, this theoretical law of equilibrium thus fails. However, this equilibrium condition is based on thermodynamic relations, i.e., is that corresponding to the average velocity of the air molecules. The molecules which have a higher velocity than the average corresponding to the temperature are capable of reaching up to correspondingly higher altitudes—beyond those that would limit the extent of the atmosphere if all its molecules had the same average velocity. Thus even in our own atmosphere, and without going beyond it into cosmic space, the law of gravitation is doing the work of Maxwell's demons in separating the faster and the slower molecules, and collecting the former in the higher regions of the atmosphere. Thus the second law of thermodynamics does not apply to the atmosphere of the earth, since kinetic molecular energy is transferred from the regions of lower molecular energy to regions of higher energy; that is, heat energy flows from lower to higher temperature, or rather flows against the thermodynamic temperature equilibrium. Furthermore, this phenomenon is not yet beyond the limits of heat energy—that is, in the range where the molecules act as separate masses and their kinetic energy thus is not heat energy but mechanical energy. In the present case, however, the phenomenon applies to the resultant kinetic molecular energy, that is, to the temperature. The average kinetic energy, and thus the temperature of the upper regions of the atmosphere, must be higher than that which corresponds to the theoretical thermodynamic equilibrium.

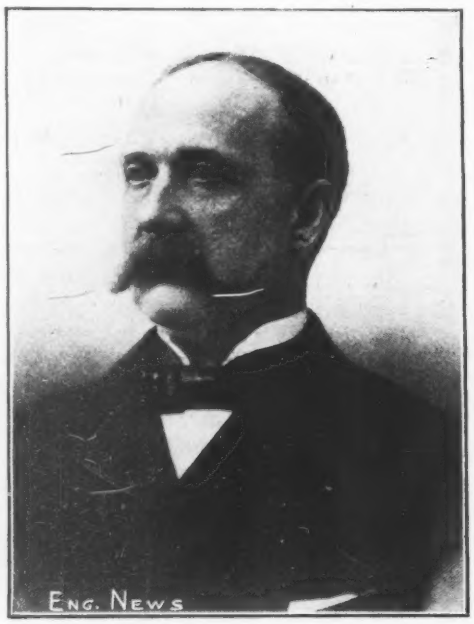
Thus we are led to the conclusion that the second law of thermodynamics is not a universal law of nature, but applies only within the limited range of thermodynamic engines from which it has been derived. It does not apply to the universe as a whole; and the conclusions derived from it, that the universe must finally come to a standstill, are not justified.

Ventilation by Individual Air Ducts has been tried at one of the public schools in Minneapolis under the direction of the engineering division of the Minnesota State Board of Health. The air was discharged through individual funnel ventilators placed beside each desk. It was found in experiments extending over a period of four weeks that satisfactory ventilation could be maintained in this way by supplying only 8 cu.ft. of air per minute per pupil as compared with 30 cu.ft. required under the ordinary fan system of ventilation. More extensive experiments are to be taken up during the coming year with a view to comparing the physiological condition of the school children under the usual fan system and the individual-funnel system of ventilation. A detailed description of the apparatus is given in an article by Frederick Bass, director of the engineering division of the Minnesota State Board of Health, in the June 7 issue of the "Metal Worker, Plumber and Steam Fitter."

James Edmund Childs

Among the several railway engineers who have advanced from positions in the construction and maintenance-of-way departments to high offices in the operating department, few have been better known in the East than James Edmund Childs, Vice-President and General Manager of the New York, Ontario & Western Ry., who died in New York City on July 16. Mr. Childs was 64 years old and had completed more than 47 years of continuous railway service.

He was born at Neversink, N. Y., in 1848. At 15 years of age he began work with the engineering corps of the New York, Oswego & Midland R.R. Four years later he became Assistant Engineer with the Chicago & Michigan Lake Shore R.R., and in 1870, Resident Engineer of the Buffalo, New York & Philadelphia R.R. The following year he was made Division Engineer of the Rochester & State Line Ry., and in 1872 accepted a similar position with the Wisconsin Central R.R.



From 1873 to 1875 Mr. Childs was Assistant Engineer on the track-depression work in Harlem of the New York & Harlem R.R. His services were again required by the Rochester & State Line Ry., and he returned to that railway as Chief Engineer and Superintendent. During this period, in 1878, Mr. Childs was elected a member of the American Society of Civil Engineers and had ever since retained his membership in the society and his association with engineers.

In 1881 Mr. Childs began his service with the New York, Ontario & Western Ry., which was organized in 1880 as the successor of the New York & Oswego Midland R.R., as General Superintendent, filling at the same time the office of Assistant General Superintendent of the New York, West Shore & Buffalo Ry. From 1886 to 1904 he was General Manager of the New York, Ontario & Western Ry., and since 1904 had been Vice-President and General Manager and the real operating head of the company.

Mr. Childs was married on Aug. 29, 1882, to Miss Mary Laura Grant, also of Neversink, N. Y., who survives him.

A Coal Mine Explosion in tunnel No. 4 of shaft No. 3, of the Lehigh & Wilkes-Barre Coal Co., at Wilkes-Barre, Penn., July 17, caused the death of four men and injured four others. The explosion is ascribed to a windy shot.

A Boiler Tube or Steam Pipe Explosion on the steamship "Principe di Premonte," of the Lloyd Sabaudo line, July 17, killed five men and injured a number of others in the boiler room. The accident occurred when the steamship was 750 miles east of Sandy Hook, running through a moderate sea. A stop of nine hours was made for repairs.

A Cloudburst swept away the lower dam of the Hondo irrigation project at Hondo, Lincoln County, New Mexico, July 17, according to press reports.

On July 18, a cloudburst caused a flood in Barren Run, near Jacobs Creek, Penn., and nine persons were drowned.

The town of Seven Troughs, Nev., is reported to have been destroyed by a cloudburst, July 18, with the loss of 20 lives. At Mazuma, in the same vicinity, five persons were killed and considerable damage was done to property, including the washing out of a mile of the track of the Nevada & California R.R.

Building Motor-Driven Ships in Scotland—Two motor vessels which have some interesting features were launched on the Clyde last week. The "Fordonian," built by the Clyde Shipbuilding & Engineering Co., Port-Glasgow, for service on the Canadian lakes, is a vessel 250 ft. long and 42 ft. 8 in. broad, with a depth moulded of 16 ft. 10 in. to main deck and 26 ft. 6 in. to awning deck. She is a single-screw ship, and is to have an 800-hp., four-cylinder, Carels-Diesel engine, constructed by the builders.

The second vessel is the auxiliary surveying ship "Y Ddraig Goch," which was launched at Old Kilpatrick, for Mr. Godfrey H. Williams, of Aberpergwm. She is 200 ft. long, and is to have a six-cylinder gas engine, developing about 225 hp. and driving a single screw. She will carry a suction gas producer, with washer complete. Anthracite coal will be used, and she will have sufficient fuel capacity for a voyage—with average weather conditions—round the world. She will have four masts with a large spread of canvas. An auxiliary gas motor will be provided to drive a dynamo for the supply of current for working the pumps, the windlass, and the capstan.

Another vessel of some interest is the ferryboat "Glencoe," which at her trials last week, attained a speed of 6½ knots. She has been built at Clynder for service at Ballachulish, and has been specially designed for the conveyance of motor cars across Loch Leven. She will carry a turntable 20 ft. long, and when a car is embarked this turntable will be swung round until it is at right angles to the vessel, its outer end resting on the jetty. The car will then be driven on board and the turntable restored to its fore and aft. position. In disembarking cars the process will be reversed. The vessel, which is propelled by a 15-20-hp., two-cylinder, Kelvin motor will have to cross Loch Leven at a place where the tide runs frequently at about seven miles an hour.

The application of the internal combustion motor as an auxiliary for the propulsion of vessels in the northern fisheries is increasing rapidly. Last year 77 of these vessels were added to the Scotch fishing fleet, bringing the total number of motor boats in the fleet to 233. It is expected that a considerable number will be added this year, for there is now no doubt regarding their commercial success.—"London Times, Engineering Supplement."

The Canadian Pacific Ry. celebrated in the last week of June the 26th anniversary of the opening of its transcontinental service. In 1886 the mileage was 4315, the road had 336 locomotives, and its gross annual earnings were $8,370,000; today the railway has a mileage of 16,000, a total of 1845 locomotives, and its gross annual income is about $120,000,000. There are 80,000 employees who are entitled to pensions on reaching the age of 65 years. The railway also owns a fleet of 75 steamships.

High-Power Wireless in Peru was inaugurated on June 16, 1912, when a pair of stations at Lima and at Iquitos was put into operation in the presence of President Leguia of Peru. The towers at Lima and Iquitos are steel-frame towers 348 ft. high, resting on an insulating ball at the base and held by three guy wires; that at Lima is on a hill 920 ft. above the city or 1370 ft. above sea level. Iquitos is about 640 miles northeasterly, on the headwaters of the Amazon; the line crosses the main ranges of the Andes Mountains, with summit elevations of some 18,000 ft. For the past three years the transmission between Lima and Iquitos has been conducted by way of four intermediate stations, transmission from Lima to Puerto Bermudez being by cable, while from here to Iquitos it was over four lengths of wireless transmission. The new installation covers the full distance without relaying, although the contractors for the equipment, the Telefunken Co., were unwilling to guarantee that this result would be achieved but reserved the right to put in an intermediate station if transmission over the full distance did not prove practicable. The Lima station has communicated with Manaos (Brazil), part way down the Amazon Valley, 1400 miles from Lima, and it has also sent messages to Panama, about 1700 miles directly north. The transmission employs a wave-length of about 13,000 ft., an exceptionally low frequency. The power equipment at Lima and Iquitos is 10 kw., while the Manaos station is only of 5 kw. power.

It is expected that the wireless system of Peru will soon be extended by the erection of a station at Paita (near the north end of the Peruvian coast line, about 600 miles northerly from Lima) and another one at Arequipa (near the southerly extremity of Peru, some 525 miles south of Lima). Besides covering the coast of Peru, these stations would serve as way stations for communication with Panama on the north and Valparaiso on the south.

Water Meters are to be gradually installed in Schenectady, N. Y., to prevent a daily waste estimated at 5,000,000 gal., according to a statement made to a local newspaper by F. W. Bently, superintendent of the water-works. Schenectady has a population of about 73,000 and uses an average of 12,000,000 gal. daily, pumped from artesian wells in the town of Rotterdam, north of Schenectady. This is an average daily consumption of 165 gal. per capita. The proposed saving in water is expected not only to minimize pumping costs, but also reduce the size of the sewage-disposal plant, which the city expects the state authorities will order it to build within the next few years.

A Patent on Reinforced-Concrete building construction was sustained by a court decision handed down on June 26 by Judge Hazel, in the western district of New York. The patent in question was No. 694,580, granted to Ernest L. Ransome, Mar. 4, 1902. The decision held that claims 5 to 10 of the patent were valid and were infringed by the defendant, who was the owner of a reinforced-concrete building. The claims sustained cover the extension of a reinforced-concrete floor to the exterior face of a building to form a belt course with an extension to form window sills or window caps. The decision, which was rendered in the U. S. District Court, has been appealed.

The Engineering Reference Library of Mr. E. L. Corthell is now arranged in the John Hay Library Building of Brown University at Providence, R. I., and is available for use by engineers. It is the especial wish of the donor that this library shall be used by practising engineers in its vicinity, as well as by the university students and faculty. Probably very few engineers have expended as much time and money in the development of a working library as has Mr. Corthell. In its files of the Proceedings of engineering societies and the back volumes of the principal engineering periodicals the library is unusually complete.

Wear of Roads by Motor Vehicles in Scotland—The largely increased cost necessary to maintain the main trunk roads in a state to suit the motor traffic of different kinds must, at no distant date, become acute, and the necessity of considering some means whereby a contribution for direct maintenance can be made by those creating the increased cost appears only fair and reasonable.

Every district in Scotland for the past few years has been experimenting with materials for laying the dust and increasing the life of the road treated, but in only a few counties has a bituminous binder been applied on an extensive scale, the cost in most other instances being the deterrent.

Since the introduction of motor-car traffic the life of the trunk roads under ordinary maintenance has been reduced from eight to ten years to four or five years, and in some cases less. The rate of expenditure has increased in Ayrshire during the last ten years by fully 30%, and the experience of other counties in Scotland is similar. If this special traffic increases in the same ratio as it has done in the past, county rates cannot maintain the roads in good condition without obtaining some relief. Formerly the traffic was slowly driven, now it is driven at a legalized speed of 20 miles an hour, and, be it observed, the speed is frequently very much greater.

In one district in Ayrshire motor wagons with a load of six to eight tons are a regular traffic carried on in competition with railways. The latter have to purchase land and equip their own road, whereas the traffic by motor wagons, although legalized on the highways, does not contribute to their maintenance, and the county is, therefore, contributing to the profits of the owners and bearing the cost of the highway maintenance. Contributions should come from this traffic toward the additional cost incurred by the use of the highway, and the same remark applies to all heavy self-propelled traffic.—(From a paper on "Scottish Roads," by Allan Stevenson, County Road Surveyor, Ayr., read before the Institution of Municipal and County Engineers).

Personals

Mr. Harry P. Willis, Assoc. M. Am. Soc. C. E., Chief Engineer of the New York State Department of Highways, has resigned.

Mr. M. J. Brew, Trainmaster of the Chicago, Rock Island & Pacific Ry., at Chicago, Ill., has been appointed Division Engineer, with headquarters at Chicago.

Mr. Waller Edwards has been appointed Publicity Manager of the Busch-Sulzer Bros.-Diesel Engine Co., St. Louis, Mo., succeeding Mr. A. O. Krieger, resigned.

Mr. B. H. Klyce, Assoc. M. Am. Soc. C. E., formerly City Engineer of Jackson, Miss., has been made City Engineer of Waycross, Ga., succeeding Mr. H. H. Pafford, resigned.

Mr. Dabney H. Maury, M. Am. Soc. C. E., who has had an office as consulting engineer in Peoria, Ill., for a number of years, will open a Chicago office at 1137-38 Monadnock Block, on Aug. 1.

Mr. J. E. Hutcheson, Superintendent of the Ottawa (Ont.) Electric Ry. since its construction, nearly 21 years ago, has been appointed General Manager of the Montreal (Que.) Tramways Co.

Mr. E. W. Grice, formerly General Manager of the Chesapeake & Ohio Ry., has been appointed Assistant to the Fourth Vice-President, and the office of General Manager has been abolished.

Mr. Ernest McCullough, M. Am. Soc. C. E., has been appointed Lecturer on mining methods at the summer school of the University of Kansas, held at Weir City, Kan., commencing July 22.

Mr. G. W. Atmore, formerly Trainmaster of the Atchison, Topeka & Santa Fé Ry., at Argentine, Kan., has been appointed Assistant Superintendent of the Northern Pacific Ry., at Duluth, Minn.

Mr. W. R. Scott, formerly Assistant General Manager of the Southern Pacific Ry., at San Francisco, Calif., has been promoted to be General Manager, in charge of operation and maintenance.

Mr. W. H. Averell, recently Assistant to the General Manager of the Baltimore & Ohio R.R., at Baltimore, Md., is now Assistant General Superintendent, with headquarters at Pittsburgh, Penn.

Dr. Charles S. Woods, City Sanitarian and Secretary of the Indianapolis, Ind., Board of Health, has resigned. Dr. Wood has had charge of the city health department work for the past 3½ years.

Mr. Newton B. Wade, for the past two years Assistant Engineer, Bureau of Drainage Investigations, United States Department of Agriculture, has been elected City Engineer of Millville, N. J.

Mr. R. H. Coulson, formerly Resident Engineer of the New York Central Lines, at Watertown, N. Y., has been transferred to Utica, N. Y., in charge of construction of the new engine-house to be built there.

Mr. Robert H. Ford, Assoc. M. Am. Soc. C. E. has been appointed Engineer in charge of track elevation of the Chicago, Rock Island & Pacific Ry., succeeding Mr. C. W. Peterson, Assoc. M. Am. Soc. C. E., resigned.

Messrs. H. L. Caldwell and E. V. Nelson have organized the Caldwell & Nelson Engineering Co., to take over the business of the late Charles W. Brown, consulting municipal and drainage engineer, at Jacksonville, Ill.

Mr. Lee Treadwell, M. Am. Soc. C. E., has resigned the position of Vice-President and Chief Engineer of the Union Bridge & Construction Co., Kansas City, Mo., and has sold his interest in the company to the stockholders.

Mr. M. K. Trumbull, M. Am. Soc C. E., Principal Assistant Engineer of the Chicago & Western Indiana R.R., and the Belt Ry., Chicago, Ill., has resigned to become Manager of the National Lumber & Creosoting Co., at Houston, Tex.

Mr. James F. Hamilton, General Manager of the Schenectady Ry. Co., has been appointed Acting General Manager of the United Traction Co., of Albany, N. Y., in addition to his previous position, succeeding Mr. Edgar S. Fassett.

Mr. W. F. Tenny, Assoc. M. Am. Soc. C. E., recently Assistant Engineer at Utica, N. Y., of the New York Central Lines, has been appointed Resident Engineer at Watertown, N. Y., succeeding Mr. R. H. Coulson, transferred, as noted elsewhere.

Mr. C. A. M. Smith, A. M. I. Mech. E., for the past five years connected with the faculty of the University of London, England, has been appointed Professor of mechanical and civil engineering at the newly created University of Hong Kong, in China.

Mr. W. M. Whitenton, General Manager of the Chicago, Rock Island & Pacific Ry., First District, at Chicago, Ill., has also been appointed General Manager of the St. Paul & Kansas City Short Line R.R., with headquarters at Des Moines, Iowa, succeeding Mr. F. C. McMillan.

Mr. Douglas B. A. Graham, Assoc. M. Am. Soc. C. E., formerly Assistant Engineer for Alvord & Burdick, Consulting Engineers, of Chicago, Ill., has accepted the position of Principal Assistant Engineer for Mr. Dabney H. Maury, M. Am. Soc. C. E., Consulting Engineer, of Chicago, Ill.

Mr. A. Findley, Master of Bridges and Buildings of the eastern division of the Grand Trunk Ry., at Montreal, Que., has retired under the company's pension system after 46 years' service. He is succeeded at Montreal by Mr. J. H. Johnson, formerly Master of Bridges and Buildings, at Ottawa, Ont.

Mr. S. I. Foster writes to us that he is not City Engineer of Amsterdam, N. Y., but that Mr. F. E. Crane, M. Am. Soc. C. E., holds that office. The statement in our issue of last week, which was taken from an official publication of the Rensselaer Polytechnic Institute, is therefore incorrect.

Mr. Harry A. Storrs, M. Am. Soc. C. E., M. Am. Inst. E. E., is now associated with the Edmund T. Perkins Engineering Co., of Chicago, as consulting electrical engineer. He was formerly professor of electrical engineering in the University of Vermont, and later in consulting practice at Denver, Colo.

Mr. Luther Conant, Jr., Deputy Commissioner of the United States Bureau of Corporations since 1909, has been appointed by President Taft, Commissioner of Corporations succeeding Mr. Herbert Knox Smith, resigned. Mr. Conant is a graduate of the Massachusetts Institute of Technology, class of 1895.

Mr. George Irving Adams, M. Am. Inst. M. E., has resigned his position with the United States Geological Survey and sailed from San Francisco, Calif., on July 12, for Tientsin, China, where he has been appointed to take charge of the mining and geological department of the National Pei Yang University.

Mr. William R. Davis, Assoc. M. Am. Soc. C. E., Chief Bridge Designer and Inspector, Office of the State Engineer of New York, has resigned. Mr. Davis has had charge of the preparation of plans and specifications for several million dollars' worth of steel work in connection with the State Barge Canal.

Mr. W. H. Peterson, Engineer of Maintenance-of-Way of the Chicago, Rock Island & Pacific Ry., at Des Moines, Iowa, has been given jurisdiction over the maintenance-of-way department of the St. Paul & Kansas City Short Line R.R., succeeding Mr. H. L. Jackson, who has been assigned to other duties.

Mr. Fred C. Dunlap, M. Am. Soc. C. E., Chief Engineer of the Bureau of Water, Philadelphia, Penn., has resigned because of ill health. Mr. Dunlap has had charge of the bureau since 1907, previous to which time he was connected with the engineering department of New York City. His resignation takes effect Sept. 15.

Mr. William O. Houston has been promoted to be Division Engineer of the Michigan Central R.R., at St. Thomas, Ont. Mr. Houston is a graduate of the University of Michigan and has been an assistant engineer with the Michigan Central R.R. for the past year. He was formerly Chief Engineer of the New Orleans Great Northern R.R.

Mr. V. R. Walling, Assoc. M. Am. Soc. C. E., formerly Superintendent of the Cananea Consolidated Copper Co.'s Ry., at Sonora, Mexico, has been appointed Principal Assistant Engineer of the Chicago & Western Indiana R.R. and the Belt Ry., at Chicago, Ill., succeeding Mr. M. K. Trumbull, M. Am. Soc. C. E., resigned as noted elsewhere.

Mr. Henry J. Saunders, Assoc. M. Am. Soc. C. E., for the past two years Resident Engineer and Principal Assistant Engineer for the Arnold Co., of Chicago, Ill., and for Ford, Bacon & Davis, of New York City, on the Conrad-Valier irrigation project in Montana, has resigned to open an office at Valier, Mont., for private practice as a consulting engineer on irrigation work.

Mr. P. W. Sothman, M. Am. Inst. E. E., Chief Engineer of the Toronto Hydro-Electric Power Commission, has resigned to engage in private consulting practice. His resignation is to take effect Sept. 1, and it is stated that he will probably be retained as Consulting Engineer by the Commission. He will be succeeded as Chief Engineer by Mr. F. A. Gaby, Assoc. Am. Inst. E. E., now Chief Assistant Engineer.

Mr. James W. Armstrong, M. Am. Soc. C. E., consulting hydraulic engineer, associated with Mr. George W. Fuller, M. Am. Soc. C. E., New York City, has been appointed Engineer in Charge of the filtration division of the Baltimore, Md., water-works. While connected with the office of Mr. Fuller, Mr. Armstrong has had much to do with the design of filtration plants for the cities of Montreal, Que., Minneapolis, Minn., and Grand Rapids, Mich. For a number of years Mr. Armstrong was with the Sewerage and Water Board of New Orleans, La.

Mr. T. Rumney, Assistant Second Vice-President of the Chicago, Rock Island & Pacific Ry., has been placed in charge of the mechanical department of the St. Paul & Kansas City Short Line R.R., and the office of Superintendent of Motive Power has been abolished. Mr. J. H. Ruxton, former Superintendent of Motive Power, has been assigned to other duties. Mr. J. B. Kilpatrick, District Mechanical Superintendent of the Chicago, Rock Island & Pacific Ry., at Des Moines, has had his jurisdiction extended over the St. Paul & Kansas City Short Line R.R. also.

Mr. Carleton E. Davis, M. Am. Soc. C. E., Department Engineer, Board of Water Supply of the City of New York, has been appointed Chief Engineer of the Bureau of Water, Philadelphia, Penn., at a salary of $10,000 per annum, succeeding Mr. Frederic C. Dunlap, M. Am. Soc. C. E., resigned, as noted elsewhere. Mr. Davis graduated from the Massachusetts Institute of Technology in 1893, and for the year following was Assistant Engineer in charge of construction of the high-service water-works at Manchester, N. H. Later he had charge of water-works improvements and additions at New Bedford, Mass., and Lewiston, Maine. From 1900 to 1904 he was Resident Engineer for the Board of Water Commissioners of Newark, N. J., in charge of surveys, plans and construction of the Cedar Grove reservoir. For a year, 1904-1905, he was Engineer in charge of sewers and water-works for the Isthmian Canal Commission on the Panama Canal. Since 1905 he has been Department Engineer, reservoir department, Board of Water Supply of the City of New York, at a salary of $7000 per annum.

Obituary

Harry Vandeveer De Hart, of the firm of the De Hart & Stafford, New York City, died at Toms River, N. Y., July 16. Mr. De Hart was formerly connected with the sales departments of Pennsylvania Steel Co., the Passaic Steel Co., and Milliken Bros.

Charles W. Brown, a consulting muncipal and drainage engineer of Jacksonville, Ill., was shot and killed in his office, on May 23, by an insane man. He was a graduate of the University of Illinois. He was a member of the Western Society of Engineers and of the Illinois Society of Engineers and Surveyors.

Jules Henri Poincaré, Professor of Mathematics and Astronomy at the University of Paris, France, died on July 17, at his home in Paris, from the bursting of an artery. He was a member of the Institute of France, a member of French Academy and many other learned societies. He was the author of many scientific treatises and was considered one of the greatest mathematicians in the world. He was born at Nancy, on Apr. 29, 1854, and was educated at Ecole Polytechnique, the Ecole Normale and the School of Mines at Paris.

Engineering Societies

COMING MEETINGS

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 26-30. Annual convention at Peoria, Ill. Secy., Clarence R. George, Houston, Tex.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 27-30. Annual convention at Chicago, Ill. Secy., W. O. Thompson, N. Y. C. car shops, East Buffalo, N. Y.

INTERNATIONAL CONGRESS FOR TESTING MATERIALS.
Sept. 2-7. Sixth congress at New York City. Secy. of organizing committee, H. F. J. Porter, 29 West 39th St., New York.

MICHIGAN GAS ASSOCIATION.
Sept. 4-6. Annual convention at Toronto, Ont., and on board steamer "Rochester." Secy., Glenn R. Chamberlain, Grand Rapids Gas Light Co., Grand Rapids, Mich.

INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.
Sept. 4 at Washington.
Sept. 6-13 at New York City. Secy., Bernhard C. Hesse, 25 Broad St., New York.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 10-13. Annual convention at Denver, Colo. Secy., A. P. Dane, B. & M. R.R., Reading, Mass.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.
Sept. 12-14. Annual convention at Glenwood Springs, Colo. Secy., Thos. F. Kennedy, 900 15th St., Denver, Colo.

NEW ENGLAND WATER WORKS ASSOCIATION.
Sept. 18-20. Annual convention at Washington, D. C. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 18-20. Annual meeting at Washington, D. C. Secy., Selskar M. Gunn, 755 Boylston St., Boston, Mass.

INTERNATIONAL CONGRESS ON HYGIENE AND DEMOGRAPHY.
Sept. 23-28. Fifteenth congress at Washington, D. C. Secy., John S. Fulton, Senate Annex, Washington, D. C.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
Sept. 24-26. Annual convention at Buffalo, N. Y. Secy., R. D. Moldenke, Watchung, N. J.

International Association for the Prevention of Smoke—The 1912 convention will be held at Indianapolis, Ind., Sept. 25-28. J. P. Brown, City Smoke Inspector of that place, is in charge of local arrangements.

Master Car & Locomotive Painters' Association—The 43d annual convention will be held at Denver, Colo., Sept. 10-13. The program includes papers on the following subjects: "Vestibule End Finish," "The Use of Interior Car Renovators," "The Most Economical Method of Removing Old Paint from Locomotive Jackets," "The Treatment and Care of Steel Passenger Car Roofs," "The Modern Method of Exterior Passenger Car Paintinfi. Including Priming and Surfacing," "The Relative Difference in the Cost of Maintenance Between Steel and Wooden Passenger Cars." There will also be an essay by Leo H. Nemzek, Chief Chemist for John Lucas & Co., Philadelphia, Penn., on "The Finish and Treatment of Passenger Car Concrete Floors."